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INSTRUCTION IN THE COLLEGE OF FORESTRY, Cornell University, has been suspended, Professors Fernow and Gifford have resigned, and their resignations have been accepted. The immediate reason for this unfortunate course of events, as stated in a resolution passed by the trustees of Cornell University, is "the failure of the State to appropriate means" to support the college. In his annual report to the trustees President Schurman said:

> The administration of the New York State College of Forestry was undertaken by Cornell University at the instance of the State, the university having neither asked for the establishment of such an institution nor been consulted concerning the terms of the act under which it was organized. But when the Legislature framed and the Governor approved a bill inviting Cornell University to conduct a great experiment in forestry in the Adirondacks in connection with a State College of Forestry, to be established at Ithaca, the university, in its loyal desire to co-operate with the State in this scientific enterprise, accepted the duty imposed by the act and addressed itself to the task with good faith, diligence, and an earnest determination to carry out the purpose of the State as expressed in the terms of the act itself.
>
> The first and all-essential step was to secure an expert into whose hands, under the general supervision of the trustees, the work might be committed. The university congratulated itself on securing the services of a gentleman who had been thoroughly trained both on the theoretical and practical sides in European forestry, who had lived many years in the United States, and who, after successful experience as a forester for private parties (among whom the late Abram S. Hewitt strongly testified to his merits and success), had for some years held the foremost position in forestry in the United States, namely, that of Chief of the Division of Forestry. From this office Dr. Bernhard Eduard Fernow came to the position of Director of the New York State College of Forestry. He outlined a plan for the conducting of scientific forestry in the tract of 30,000 acres in the Adirondacks which the State had assigned to the College of Forestry for that purpose. The plan grew out of the actual condition of the tract in question. It was a scheme to substitute valuable soft woods for old and rotten hard woods. This meant denudation and replanting. But there is a general prejudice against cutting even old trees and an impatience to wait as long as 50 years for new ones to take their place. Both feelings have been invoked by the critics of Director Fernow's work in the Adirondacks. And without going into further detail, the result now is that the State, speaking through its organized authority, desires to have the work stopped. The university stands by its expert. But the university has not the means, even if it had the power, in the absence of State appropriation, to carry on the work of the College of Forestry.

Although the public sentiment against clearing the State forest lands was reflected in a report by a legislative committee, condemning that course, yet the last Legislature made an appropriation to continue the work of the College of Forestry. Governor Odell vetoed that item in the annual appropriation bill, and added some words of severe criticism.

ANOTHER WATER FILTRATION COMMISSION at Pittsburg is talked of, how seriously we cannot say. It is said that the mayor, Mr. Wm. B. Hays, favors another commission. He has also been reported as averse to "giving any part of the city filtration until the whole city can be supplied" with filtered water. A part of the city is supplied from an independent source by the Monongahela Water Co., whose contract will not expire for several years. While, for one excuse or another, further steps for an improved water supply for Pittsburg are postponed hundreds of citizens are dying from typhoid fever. The statement that "865 persons died from typhoid fever in the city of Pittsburg in the past two years and four months" (Pittsburg "Chronicle," June 6) appears to make no impression upon citizens and city officials whose inaction in the face of a great and continuing calamity is a source of endless wonder to those who realize the deadliness of sewage-polluted water.

THE PASSAIC RIVER POLLUTION SUIT is making slow but sure progress. In this suit 43 owners and users of riparian land, or of water from the river, joined in a claim for some $2,500,000 damages on account of the discharge of sewage into the river by the city of Paterson. The city entered a demurrer to the effect that the complainants must sue individually. This demurrer was overruled by the lower court, but has been sustained by the New Jersey Court of Errors and Appeals. In this latest decision, however, the court clearly affirms, or reaffirms, the right of riparian owners to an injunction against sewage pollution or else to compensation for damages. The only gains in the decision, therefore, would seem to be delay and the hindrances to suits created by the necessity of individual instead of joint action.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Illinois Central R R. near Raymond, Iowa, June 19. Ten persons, including both engineers and firemen, were killed and three passengers were injured. The passenger train which had the right of way collided with a freight train on a curve in a cut. The freight crew is said to have misunderstood orders.——The second section of passenger train No. 7, on the Delaware & Hudson R. R., collided near Dresden, N. Y., with a freight train, June 20, killing four men and seriously injuring two more. The freight train crew did not see the signals on section one of train No. 7, and pulled on to the main track from a siding just in time to meet section two of the passenger train.——A Great Northern train of 60 coal cars broke in two on a grade near Spokane, Wash., June 22, and ran three miles down hill, finally jumping the track. A laundry and a house were wrecked, killing three persons and injuring nine others.

A BLOW-OUT OF COMPRESSED AIR in the south heading, section B, of the Boston Subway Extension tunnel under Boston Harbor, on June 19, resulted in a cave-in that buried one or more men and injured several others. The tunnel passes under the harbor from Atlantic Street Station to East Boston, and in our issue of June 4 will be found profile and description of the tunnel work. A shield was being used with an air pressure of 12 lbs. per sq. in., and, according to local newspaper reports, one of the workmen struck his pick into a seam of quicksand, whereupon the compressed air began to escape with a loud noise that was called an "explosion of compressed air." One of the inspectors who was in the shield at the time of the accident reported that during the first outburst the air escaped for about 10 seconds, then stopped for a second, then escaped for a minute, stopped again and finally escaped steadily for 15 mins. Another inspector estimates the time of air outrush at about 5 mins. The velocity of outgoing air was so great as to draw one workman into the earth where he was buried. The "explosion" has caused a depression in State St. 10 ft. deep and 50 ft. square, and several buildings are leaning badly. Thirty men were in the drift at the time of the accident, and it is remarkable that more were not killed. The tunnel itself was not seriously injured.

A BRIDGE APPROACH COLLAPSED, June 16, at Eau Claire, Wis., under the weight of some 200 people, 40 of whom were more or less injured. The accident occurred during a street carnival and hundreds of people were on the Madison St. bridge and its approaches. The section of the approach that collapsed was 40 ft. long.

ANOTHER LOCOMOTIVE CAB-SIGNAL SYSTEM, as a substitute for the block system, is to be exploited by the Railway Safety Signal Co. of 256 Broadway, N. Y., which is now offering stock to investors. Among the directors of the company is Mr. Ira A. Place, General Attorney of the New York Central & Hudson River R. R. Co.

AN INTERESTING LIBEL SUIT has been brought against the "Daily News," of Ithaca, N. Y., on account of an editorial in its issue of May 28, in which, according to the "News," "a protest was made against endangering the lives of Ithacans by building the dam in Six Mile Creek gorge." The contractors claim that the dam they are building will be safe, and that the circulation of statements that it will be unsafe is an injury to their reputation. Damages to the amount of $50,000 are asked.

THE PROPOSED SUBSTITUTION OF EYE-BARS for wire cables in the new Manhattan Bridge across the East River was discussed before the finance committee of the Board of Aldermen on June 19. Commissioner Lindenthal's plans for the use of eye-bars were opposed by Messrs. O. F. Nichols, Gus C. Henning, R. S. Buck and Foster Crowell.

WELL-PRESERVED IRON GIRDERS and beams are exhibited by the floor framing of a building, now being demolished, at the corner of William St. and Exchange Place, New York City. This building dates back of the Civil War. It has brick walls faced with marble, and floors of earth filling on all-iron framing. The arrangement and details of the floor construction are notable. We shall describe and illustrate them more fully in a coming issue. For the present we may note that the beams and girders show only spots of rust, the general surfaces showing either the original paint or, where the paint has scaled off, the oxide scale of the rolling mill.

A NEW DESIGN of high-speed passenger locomotive is to be built by Henschel & Sons, of Cassell, Germany, from designs by Herr Wittfeld, Consulting Engineer to the Prussian Department of Railways. The locomotive will have two pairs of driving wheels and four-wheel leading and trailing trucks. The driving axles have inside cranks driven by an inside high-pressure cylinder and outside cranks driven by low-pressure cylinders on each side. The inside crank is set at 90° to the outside cranks. The boiler has 2,766 sq. ft. of heating surface. The locomotive is designed to run at speeds of 130 to 200 kilometers per hour.

ELECTRIC CANAL TOWAGE has been introduced as a part of the Miami & Erie Canal, and is to be extended over the entire route from Cincinnati to Toledo, O. This work is being done by the Miami & Erie Canal Transportation Co., of Cincinnati, and we are informed by Mr. F. A. Little, Chief Engineer, that on June 16 alternating current motors were used for the first time, and with success. Direct-current motors have been in use temporarily for some time. The power is rented from the Cincinnati Edison Co. This is 60-cycle alternating current, and is transmitted to the canal company's transforming station. There it is transformed by synchronous motor generators from 60 cycles to 25 cycles, then stepped up by static transformers to 33,000 volts and transmitted to the substations, which are about 14 miles apart. It is there stepped down to 1,100 volts for the trolley wire, from which the current is taken by the electric locomotive through step-down transformers reducing the voltage to 200 volts, which is the voltage used by the locomotive. The speed of the locomotives is about 3½ miles per hour, the state authorities not permitting a speed of over 4 miles per hour. The largest fleets yet hauled consist of six boats, although the locomotives are capable of towing 10 or 12 boats. The traffic is increasing rapidly and in a short time the number of boats in a fleet will be increased.

THE OIL FIELDS OF ALASKA are attracting the large oil producers and consumers of the United States. The Southern Pacific R. R. Company uses about 10,000 barrels of oil a day, of which California furnishes only about one-third. The company has recently purchased the steamer "Albion," which is being fitted out for the Alaska petroleum fields under the management of Prof. Treadwell, who is accompanied by seven coal and oil experts. They will go first to the Kyak Islands and the Controller Bay district. Reports of the outfitting of other similar expeditions indicate that Alaska may ultimately become better known as an oil than as a cold and gold producer.

THE 120-TON FLOATING DERRICK FOR THE NORFOLK NAVY YARD.

One of the largest floating derricks ever constructed has recently been installed at the U. S. Navy Yard at Norfolk, Va. This derrick has a lifting capacity of 120 long tons and is intended for handling armor, plate, ordnance, boilers and other heavy weights to and from naval vessels. Bids for the construction of the derrick were invited by the Bureau of Yards and Docks in September, 1901, and the contract was awarded to Snare & Triest of New York city on designs prepared by Mr. Frank Miller, Civil Engineer, of 39 Cortlandt St., New York city. The subcontractors for the hoisting machinery were the Lidgerwood Manufacturing Co., of New York city.

The designing engineer chose timber construction for the barge and substituted creosoted sheathing for copper to prevent galvanic action. Otherwise the original terms of the specifications were followed closely.

BARGE CONSTRUCTION.—The barge is constructed of the best quality of yellow pine timber, and is stiffened both longitudinally and transversely by steel trussed girders. Fig. 2 is a diagram plan of the barge showing the location of the girders. These girders have double angle top and bottom chords and a double triangular web system. They comprise a center girder running from end to end of the barge; two long side girders between transverse bulkheads; two short girders located amidships, and six transverse girders, which brace the longitudinal girders together. The hull construction proper is shown by Figs. 3 and 4. These drawings show the dimensions of the hull timbers and the method of framing them so fully that a description of these details is unnecessary. The construction is very heavy throughout, and it will be noted that a very stiff deck framing and sheeting has been provided. This last was rendered particularly necessary since the barge will often have to carry very heavy concentrated loads on its deck. Another point to be noted is the connection of the steel trusses to the hull framing, as shown by the transverse sections of Fig. 4.

To trim the barge and maintain the necessary freeboard when lifting the maximum load over one side, it is fitted beneath deck with six water tanks on each side, as shown by Fig. 2. The tanks between transverse bulkheads are rectangular in shape and are made of steel plate, but the bow and stern tanks, being of irregular shape, are made of wood. These tanks have an aggregate capacity of 45,000 gallons, and are emptied and filled by means of an 8-in. centrifugal pump, with a capacity of 2,000 gallons per minute. This pump has a hose connection and supply. It can shift the water from one side to the other in about 25 mins. The arrangement and dimensions of the piping and valves and the location of the pump are clearly shown by the drawings of Fig. 2. The valves are operated from the deck level by means of the wrench and rod shown at a, Fig. 2. In addition to the ballast tanks there is a boiler feed water tank located beneath deck at the stern of the barge. This is a timber tank.

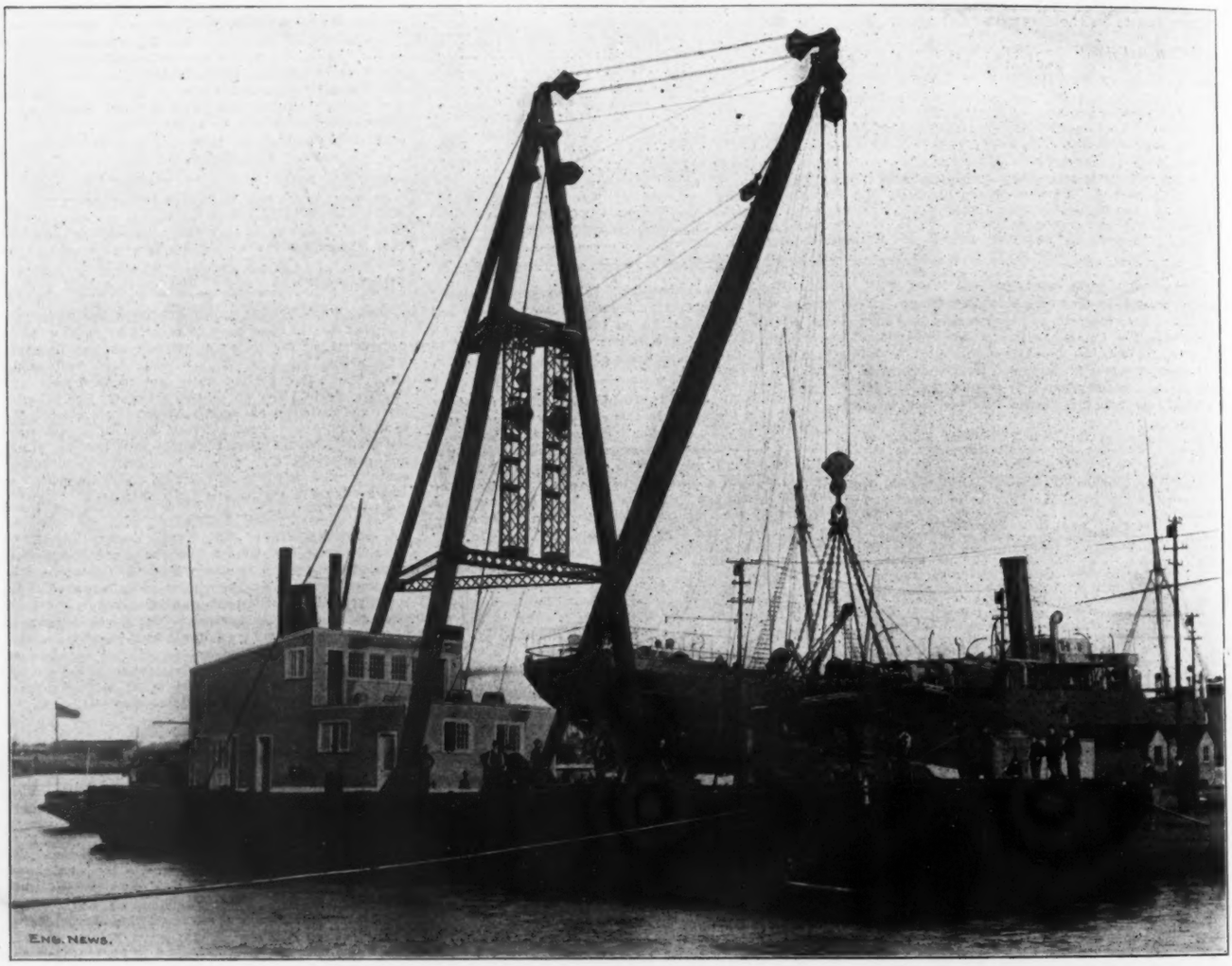

FIG. 1. VIEW OF 120-TON FLOATING DERRICK FOR THE U. S. NAVY YARD AT NORFOLK, VA.
Frank Miller, New York, N. Y., Designing Engineer; Snare & Triest, New York, N. Y., Contractors.

GENERAL DESCRIPTION.—The derrick as constructed is shown by Fig. 1, which is a view taken during the course of the builders' tests. As will be seen, the construction consists of a boom derrick carried on a timber barge. The specified requirements to be met in the general design were in substance as follows:

> The pontoon or barge may be of open-hearth steel or of wood, and if of the latter shall be suitably coppered. The derrick or crane superstructure shall be of open-hearth steel and may be of any design, provided it has sufficient reach, height and clearance to place ordnance, machinery and boilers on board the U. S. battleships or to remove them from the same. It shall have a working capacity of 120 gross tons at a clear distance of 20 ft. from the side of the barge and of not less than 60 tons at a clear distance of 40 ft. It shall be designed with a factor of safety of 4 under all conditions of loading. The hoisting mechanism shall be power-driven with a safety factor under maximum specified load of not less than 4 for all fixed or movable parts and not less than 8 for all flexible parts. For loads of 60 tons and over the speed of hoist shall not be less than 5 ft. per minute, and for loads of less than 60 tons not less than 10 ft. per minute.

The deck house, as will be seen by Fig. 1, is located abaft the forward legs of the derrick tower and consists of two stories. The machinery room and boiler room are on the deck floor and are separated from each other by a transverse partition so as to shut off as much as possible the heat from the boiler room. The boiler room is the full height of the deck house, but the machinery room is only one story high and over its rear end and forward of the boiler-room partition there is an operators' room. This room is connected by stairway with the machinery room, but all operations are controlled from the second floor where the levers are connected to a quadrant. The view, Fig. 1, shows the windows and doors of the operator's room, which give him a clear view of the derrick movements. The deck house is built of timber and the roof boarding is covered with heavy canvas, painted.

OPERATING MACHINERY.—The operating machinery is all located on the deck floor of the house. Fig. 4 is a plan of the location. It consists of two vertical 83 × 120-in. boilers, a hoisting engine and a swinging engine. The swinging engine is located forward and is a double drum horizontal engine with 9 × 10-in. cylinders. The e has one. Block d also carries an eye which permits it to be attached at will to deck hooks. It will be understood that there are two sets of sheaves and blocks and two swinging ropes as shown in Fig. 5, one on each side of the derrick boom. To swing the boom to starboard the blocks d are attached to the deck hooks on the starboard from the peak pivot of the A-frame and is pivoted to a deck casting set midway between the legs of the A-frame. Details of the pivot casting and of the supporting frame on which it rests are shown by Fig. 10. The supporting frame it will be perceived is riveted to the double transverse girder built amid-

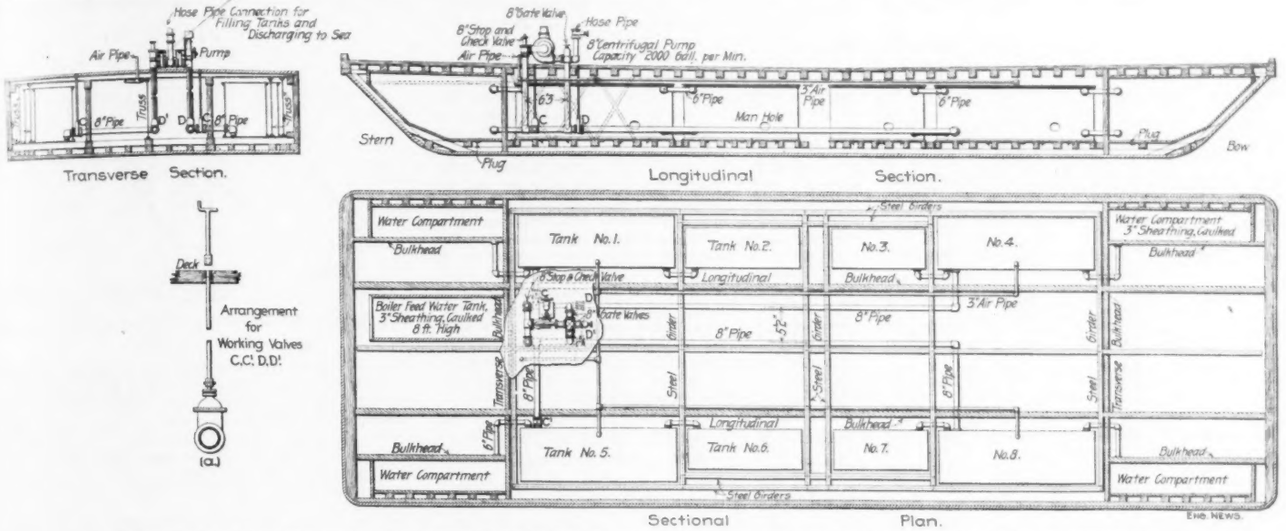

FIG. 2. PLAN AND SECTION OF FLOATING DERRICK BARGE, SHOWING WATER BALLAST TANKS AND MACHINERY.

ropes from the drums pass up through hoods in the deck-house roof to the swinging sheaves and blocks, as is described further on. The hoisting engine is a 10 × 12-in. double cylinder, link motion, double drum engine. The drums are each 18 ins. in diameter and have 56-in. faces. Each drum has its own gear and brake. The drum gears have 2¾-in. pitch and 10-in. faces and are geared 18 to 109. The intermediate gears have 1¾-in. pitch and are geared 15 to 107, making a total gear reduction of 42 to 1. The crank shaft is 3½ ins. in diameter, the intermediate shaft 5½ ins., and the drum shaft 8 ins. The ropes from the hoisting-engine drums pass up through hoods in the deck-house roof to the boom sheaves.

Crucible cast-steel wire ropes are used for hoisting and swinging. The course of the swinging ropes is discernible in Fig. 1, but is more clearly shown by the diagram, Fig. 5. Th's sketch shows the course of one rope only, but the sheaves and blocks through which the other rope runs are exactly the same, but are located on the opposite side. Coming from the deck-house hood the rope side, and to swing to port they are attached to the deck hooks on the port side. To hold the boom steady one block is attached to starboard and the other to port and the ropes hauled taut. The course of the hoisting ropes is clearly shown by Fig. 1 and needs no special description.

The centrifugal pump is operated by a small vertical engine connected directly to the pump shaft.

DERRICK CONSTRUCTION.—The derrick proper is a steel structure throughout and is rigidly attached to the frame work of stel girders built within the scow. The standing structu.e consists of an A-frame and back stay and its general construction is quite clearly shown by Fig. 1. It will be observed that the A-frame legs and the back stay are all rectangular in section with one side latticed. The bracing between the A-frame legs and the back stay is sufficiently shown by Fig. 1. Practically the only details of the standing structures that call for further mention are the footings and the connection at the peak. The footings for the A-frame legs are shown by Fig. 6, and that for the back are ships within the barge as shown by Fig. 2. Details of the boom construction proper are shown by Figs. 11, 12 and 13. Fig. 11 shows the construction at the peak or top; Fig. 12 that at the bottom or foot and Fig. 13 shows a midlength portion including typical splices and interior bracing.

The drawings Fig. 6 to 13, inclus.ve, show the principal structural details of the derrick so fully that little comment is required. Some of the main dimensions will be given, however, to illustrate the general magnitude of the structure. The boom is 88 ft. long from center to center of pins and is about 24 × 33 ins. in cross-section at the middle. The A-frame legs are 87 ft. 8 13-32 ins. long and about 20 ins. square in section. The back stay is 95 ft. 3 23-32 ins. long and 12 × 15 ins. in cross-section.

The steel and other metal used in the construction of the derrick was required to conform to the following specifications:

STEEL.—All steel shall be made by the open-hearth process. Acid open-hearth steel shall contain, on cast analysis, not to exceed 0.08% of phosphorus, nor to exceed 0.05% of sulphur. Basic open-hearth steel shall contain, on cast analysis, not to exceed 0.05% of phosphorus,

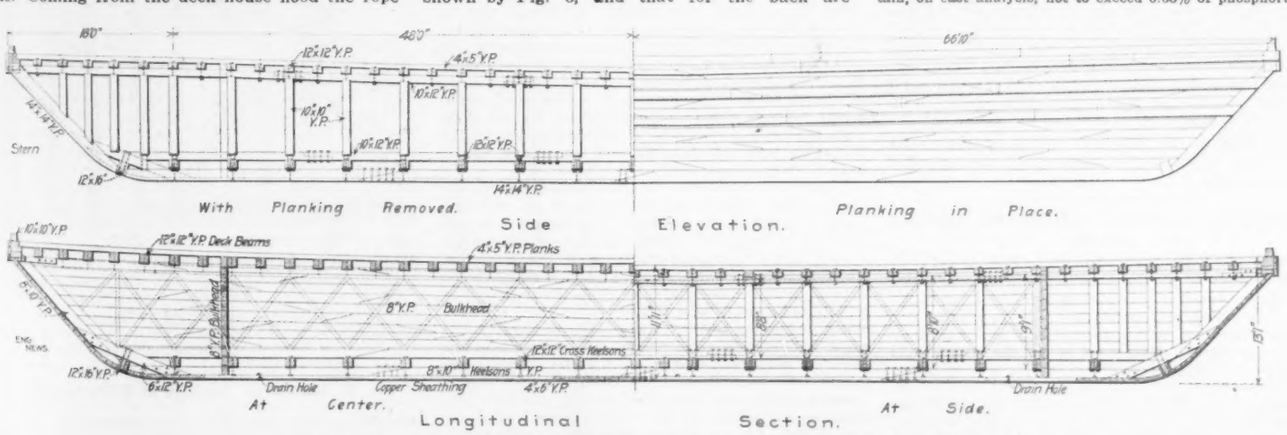

FIG. 3. LONGITUDINAL ELEVATIONS AND SECTIONS OF FLOATING DERRICK BARGE.

passes to sheaves a and b. The casings of these sheaves are hinged on vertical journals so that they swing horizontally to correspond with the vertical plane of the boom. From sheave b the rope passes to the hanging sheave c and thence to the blocks d and e, around which it is rove as indicated. Block d has two sheaves and block shown by Fig. 7. It will be understood that these footings are connected with the steel girders within the barge. The connection of the back stay to the A-frame at the peak is shown by Fig 8, and Fig 9 is a detail of the peak casting and pivot of the A-frame.

The boom, as will be seen from Fig. 1, is swung

nor to exceed 0.04% of sulphur. Carbon manganese, and other elements shall be well balanced in both kinds of steel, and unusual variations shall be cause for special testing and investigation before acceptance. Check analysis on finished material shall be made for each cast of steel and shall not show a variation from the cast analysis exceeding 50% for any element. Full cast and check analyses shall be furnished by the manufacturer, and check analyses shall be made on drillings selected by the inspector and entered under his private mark.

TESTS.—Acid open-hearth steel in plates, shapes, and bars shall show on test a maximum strength of not less than 60,000 nor more than 70,000 lbs. per sq. in.; an elongation, after fracture, on an original length of 8 ins., of not less than 22%, and a reduction of area, at fracture, of not less than 40%. Basic open-hearth steel in plates, shapes and bars shall show on test a maximum strength of not less than 55,000 nor more than 65,000 lbs. per sq. in.; an elongation, after fracture, on an original length of 8 ins., of not less than 25%, and a reduction of area, at fracture, of not less than 45%. Both acid and basic open-hearth steel in rivets and rivet rods shall show on

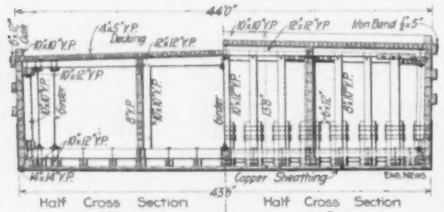

Fig. 4. Transverse Sections of Floating Derrick Barge.

test a maximum strength of not less than 52,000 nor more than 60,000 lbs. per sq. in.; an elongation, after fracture, on an original length of 8 ins., of not less than 25%, and a reduction of area, at fracture, of not less than 50%.

STEEL CASTINGS.—Steel castings shall be of acid open-hearth steel, and shall show on test, after annealing, a maximum strength of not less than 60,000 lbs. per sq. in., and an elongation, after fracture, on an original length of 2 ins., of not less than 20%. All steel castings shall be carefully and thoroughly annealed. The elastic limit of all steel shall not be less than one-half the maximum strength.

BENDING TESTS.—Specimens from plates, shapes, and bars shall bend, when cold, 180° around once their thickness; when at or above a red heat, 180° flat, and after quenching from a dark-yellow heat in water at a temperature of 80° F., 90° around twice their thickness; all without rupture on the outside of bent portion. Specimens from rivets or rivet rods shall bend 180° and close tight without rupture on outside of bent portion under any of the above conditions. Specimens from steel castings shall bend 90° around three times their thickness without rupture on outside of bent portion.

The same specifications controlled the character of the metal employed in the girder frame built within the barge.

The derrick was officially tested on March 26, 1903, and satisfactorily fulfilled all the specified requirements.

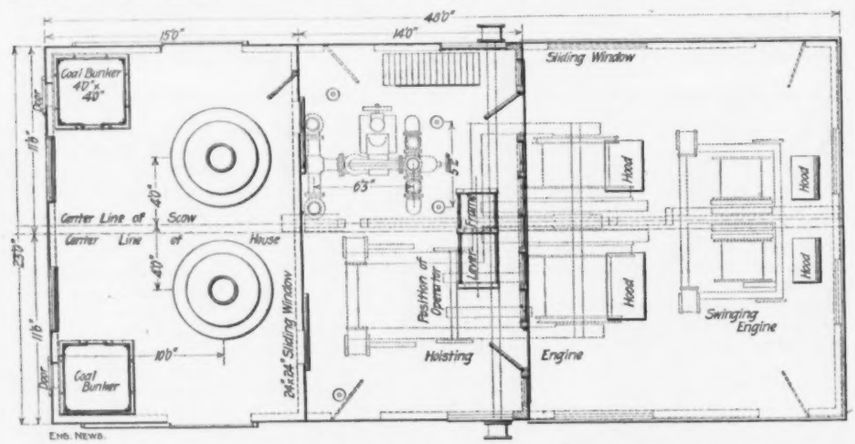

FIG. 4½. PLAN OF DECK HOUSE, SHOWING ARRANGEMENT OF OPERATING MACHINERY.

ALTERNATING CURRENT MOTORS FOR VARIABLE SPEED.*

By W. I. Slichter,† Jun. Am. Soc. M. E.

The impression is very general that a variable speed cannot be obtained with an alternating current motor, and that if an alternating current plant is to be installed, the idea of obtaining a variable speed drive of any of the tools must be abandoned. This is not so, and the object of this paper is to show the possibilities of this type of motor, and to point out its limitations. It must, however, be understood in the first place that it is not claimed for the alternating current motor that it can compete with the direct current type where continual variations of speed, throughout a wide range, are required, as the latter motor is usually superior in efficiency under these conditions.

Let us assume, then, that the problem to be solved is a case where an alternating current plant is desirable for general reasons, such as distance of transmission or availability of power, and that a considerable amount of the power is used in constant speed work, but a certain portion of the work requires a variable speed. What is the most appropriate and most efficient method of obtaining the variable speed? The speed of an alternating current motor may be controlled in a number of ways:

(a) By varying the potential applied to the primary of a motor having a suitable resistance in the secondary.

(b) By varying the resistance in the secondary circuit.

(c) By changing the connections of the primary in a manner to change the number of poles.

(d) By varying the frequency of the applied voltage.

For the benefit of those not familiar with the polyphase induction motor, a general view of its characteristics may be desirable. These characteristics are very similar to those of the continuous current shunt motor—that is, at a constant impressed voltage and frequency the speed tends to be constant, and a considerable change in load will not cause an appreciable change in speed. As the load increases, the speed drops gradually to a critical point, usually about 15 to 20% below the normal value, and then the motor breaks down completely if the load is any further increased. The same action occurs exactly if the load is kept constant and the voltage is decreased, but if the frequency of alternation of the impressed voltage is decreased, the speed will decrease in exactly the same proportion. That is, for a given frequency and a given number of poles in the motor, the speed is practically fixed and independent of all other effects. The one exception to this last rule is the effect of the resistance (or losses) in the secondary (usually the rotating) member.

The drop in speed from the synchronous value is directly proportional to these losses. Thus, by increasing the resistance of this circuit, any desired speed may be obtained at the expense of these losses. With the increased resistance, the speed at which the motor breaks down may be reduced to a very low value, even to zero speed. Thus, by reducing the voltage applied to the motor for a given torque, the effect is produced of overloading it, and the speed drops. These characteristics are equally true for the two-phase or three-phase motor, of course, as the two motors are practically identical in their construction.

In this connection it should be remembered that a variation of an alternating voltage may be obtained by means of a reactance or compensator with a very small loss of energy, whereas with a continuous voltage the loss of energy is usually proportional to the variation in voltage. Taking up these methods in the order enumerated, we will analyze their characteristics.

POTENTIAL CONTROL.—In this a suitable reactance or "compensator" reduces the line voltage to the fractional value desired. In this reduction the energy lost is only about 5% of the amount transformed. The induction motor should have a very large resistance in the secondary, which is preferably of the squirrel cage type. This resistance gives the motor a speed characteristic such that its full load speed is some 10% less than that of a normal motor, and as the load is increased the speed will fall to about 30% of this value without the motor "breaking down" or falling out of step, which in the normal motor usually takes place at about 80% of the full load speed.

Such a motor would have the following characteristics, assuming its synchronous speed as 1, and the voltage applied as 100. (This is based on a 50 HP., 40 cycle motor, at 800 revolutions per minute, as an instance.)

For constant full load (50 HP.) torque at various speeds:

	Speed.	Volts.	Efficiency.	Losses, motor. KW.	KW. Comp.
Full load speed.....	.89	100	81	8.8	0.0
Three-quarter load speed	.67	66	59	18.5	1.0
One-half load speed....	.45	57	37	32.0	2.0
One-quarter load speed.	.22	56	17	45.7	3.5
Normal motor (full speed)	.98	100	88	5.0	0.0

From this we see the principal and worst characteristic of this scheme. The increased losses in the motor (thus increased heating) with the decreased speed. This means that the motor must be larger than normal.

RHEOSTAT CONTROL.—In this scheme the secondary or rotor must have a definite winding (as opposed to the squirrel cage, which is cheaper) with slip rings and brushes to lead out the current. The friction and resistance losses due to these brushes decrease the efficiency of the motor somewhat. The secondary is usually wound for a higher voltage and less current than in the standard or normal motor, to minimize these losses. The action of this method is based on the principle that, in an induction motor, the drop in speed for any given torque is proportional to the resistance of the secondary circuit. This scheme would show the following characteristics for the same motor as before at 50 HP. torque, constant:

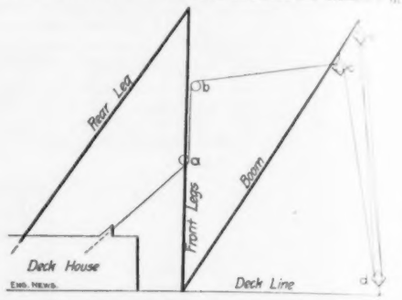

Fig. 5. Diagram Showing Operation of Boom Swinging Mechanism.

	Speed.	Volts.	Efficiency.	Losses, motor. KW.	Rheo. KW.
Full load speed.....	.98	100	86	5	0.0
Three-quarter load speed	.72	100	65	5	9.0
One-half load speed....	.48	100	43	5	18.5
One-quarter load speed.	.24	100	22	5	28.0
Normal motor (full) ..	.98	100	88	5	0.0

As will be seen, this method gives a higher efficiency throughout, but particularly excels the previous method in having so much smaller losses in the motor itself, thus permitting of a smaller design and less danger of damage. The losses are concentrated in a rheostat, which is a cheaper piece of apparatus and less liable to damage, being of iron and asbestos usually, instead of high grade insulating materials, as in the motor proper.

CHANGEABLE POLES.—By using a pitch of winding which is commensurable with two numbers of poles, we may build a motor which will operate with either 4 or 8, 6 or 12, etc., poles, by a slight change of the connections. Or by a more intricate arrangement of windings a change from 4 to 6, 6 to 8, etc., may be made. In this arrangement it is necessary to use a squirrel-cage armature, since it is suitable for any number of poles, and the pitch of the primary coils has to be made some compromise value between the normal pitch of the two combinations, so it is usually not the best or most effective pitch for either number of poles. Therefore the constants of this motor should not be expected to be as good as those of the standard motor. Of course such a motor operates advantageously only at two speeds corresponding to the synchronous speeds of the two arrangements. Thus, a 12 and 6-pole motor at 40 cycles would operate at either 400 or 800 revolutions respectively. If a wider range is desired, the potential control scheme first mentioned may be combined with it.

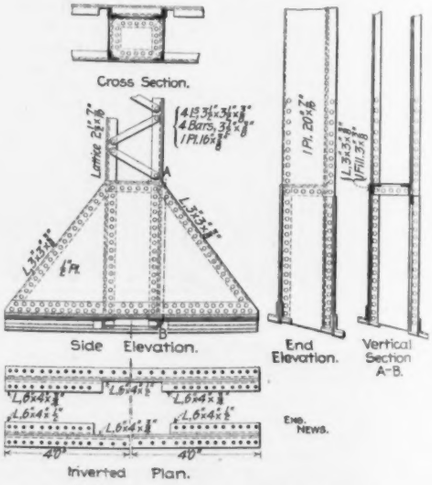

Fig. 6. Details of Footings of A-Frame Legs.

*A paper presented at the Saratoga meeting of the American Society of Mechanical Engineers, June 23-26, 1903.

†Electrical Engineer, General Electric Co., Schenectady, N. Y.

For a motor operating at full and half speeds, say with 6 and 12 poles for 800 and 400 revolutions, we would have:

	Volts.	Eff.	Losses.
Full speed, 50 HP.	100	86	5.8
Half speed 25 HP.	100	74	6.6

Thus, for full load torque at half speed we get efficiency almost double that obtained with the other methods, but what losses there are are in the motor itself, as in the first case. The losses are about the same in the two cases;

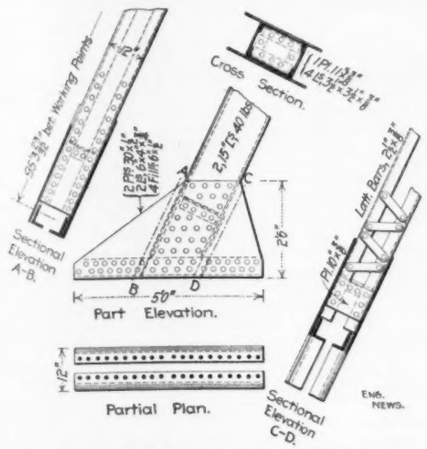

Fig. 7. Details of Footing for Backstay.

thus the ventilation being half in one case, the heating is greater at the lower speed.

VARIABLE FREQUENCY.—Every induction motor tends to run at synchronous speed—that is, at a speed equal to $\frac{60 \times \text{frequency.}}{\frac{\text{Poles}}{2}}$ Thus, if a different frequency is impressed on the motor, it will run at a different speed. Some installations have been made where two or three alternating current generators are used to obtain different frequencies, and these circuits are carried around the shops by various sets of lines (usually three in each set) and the motor connected to the lines giving the frequency and speed desired. For normal losses in the iron the voltage must vary with the frequency. Thus for full and half speed we have:

	Volts.	Eff.	Losses.
Full speed, 50 HP.	100	88	5
Half speed, 25 HP.	50	87	2.8

Generators have been built having two stationary armatures in the same frame and two revolving fields, with a different number of poles on the same shaft to give the multiple frequency desired. An application of this principle, which is very pretty theoretically, is that of a very small variable speed induction motor (whose losses are negligible) which drives a commutator feeding the primary of the load machine; by a suitable control of the little motor any desired frequency may be supplied to the load machine from zero to full value, thus it may be started and run at any desired speed. A variation of this is to attach the commutator to the shaft of the load machine and the brushes to the shaft of the controlling motor, thus when the load machine is standing still the brushes revolve at almost full speed on the commutator, and a very low frequency is obtained in the commutated circuit. As the load machine speeds up, the difference in the speeds of the commutator and the brushes decreases, and hence the frequency increases until that time when the commutator and brushes are revolving together at the same speed when there is no commutation and the load machine receives full frequency.

SUMMARY.—From these descriptions it will be seen that the changeable pole and variable frequency methods are the most efficient, but do not permit of a variation through a wide range of speed. The rheostatic control is the simplest and easiest of control, giving a range from standstill to full speed, but is not as efficient as the first two, although more efficient than potential control. The last mentioned has the disadvantages of low efficiency and considerably increased heating in the motor itself, and is also unstable at low speeds, say below one-third speed. That is, a small variation in torque or a smaller variation in voltage will cause a considerable variation in speed.

The potential control is used where moderate variations in speed are wanted, not reaching to less than half speed for instance, and where the load is intermittent, not giving the motor a chance to get too hot. Its great disadvantage is the amount of current it takes at starting, which causes considerable disturbance in the supply circuit, flickering of lights, etc., due to the drop in voltage. The motor used is a cheaper one to build (for the same size) than the others, but if anything like continuous running is desired, the motor must be larger, thus much of this advantage is lost.

One advantage of this motor is that it may be totally enclosed for use in powder mills, oil refineries or where much dust or corrosive vapor is encountered, as it may be controlled from a distance without increasing the number of wires.

The rheostatic method is particularly adapted where frequent starting and low speeds are required, as it causes no unusual drain on the supply system when starting. Thus it is used for hoists, elevators, etc.

The changeable pole system has the same disanvantages in starting as the potential control. For long-continued running at only two different speeds it is excellent and has constants comparable with those of a continuous current motor.

To vary the frequency of alternation for the motor requires an increased investment in generating station or auxiliary apparatus and line copper, and the greater the number of speeds desired the greater this complication; but in its action and economy it is equal to any.

One point which is important to bring out is that with the changeable pole and changeable frequency systems the motor will not vary appreciably from the set speed for changes of load, while with either potential or rheostatic control, a change of load will cause an appreciable variation from the desired speed, requiring readjustment of the potential or resistance to bring the speed to the desired value again.

LOSS BY ELECTRIC LIGHTING COMPANIES THROUGH POOR METERS AND TRANSFORMERS

At the recent meeting of the National Electric Light Association, Mr. Chas. F. Scott read a paper on the technical school graduate as an electric station superintendent, in which he set forth the experience of one young man in converting a losing business into a profitable one. Information which probably relates to the same case has been furnished to us by the Westinghouse Company's publication department, and we print it as follows:

It is well known to station managers that the poor financial condition of lighting and power companies is often due to the excessive losses arising from the use of old types of meters and transformers. Such meters run slow after being in use for some time, on account of increased friction in the moving parts, which can usually be traced to heavy moving elements, rough commutators, and very often to the dust, which, sifting through poorly sealed cases, lodges in the movements. The source of these losses has been recognized and has resulted in many cases in the old apparatus being replaced by that of modern characteristics. This article reviews the experience of a station which has made such a change.

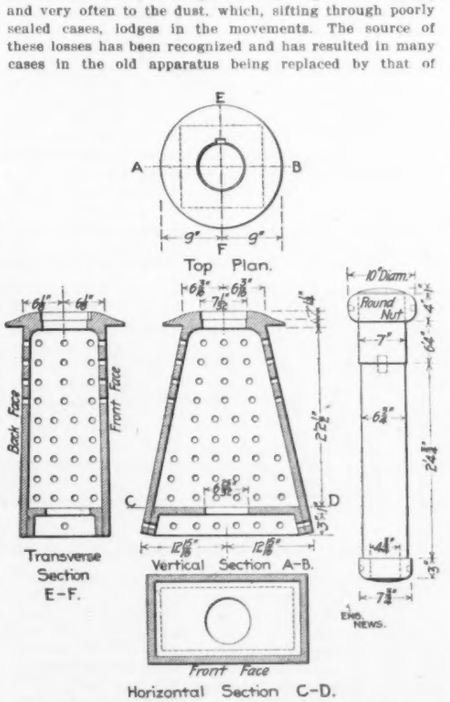

Fig. 9. Details of Peak Casting for A-Frame.

The central station referred to is operated by steam power furnishing current for lighting residences and business places, principally the former. During the year 1899 the plant was operated during the night hours only, and there were in service on its circuits 353 transformers and 406 meters, all of old types. The customers were metered.

Being satisfied that the distributing system was very inefficient, the Superintendent decided to demonstrate this to the management. There being no primary wattmeters on the switchboard for measuring the total output of the station, no comparison could be made with the amount of current paid for, and he was compelled to arrive at this comparison by a different method. After considering the merits of the various wattmeters on the market he purchased a 10-amp., 100-volt Westinghouse round pat-

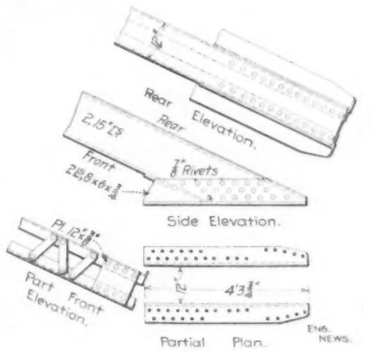

Fig. 8. Details of Connection of Backstay to A-Frame at Peak.

tern wattmeter, which was installed in a residence in series with a 5-amp. meter of the type then commonly in use on the circuits. Before making the test the old type meter was completely overhauled and cleaned.

At the end of ten days the old meter indicated a consumption of 24-KW. hours, and the Westinghouse wattmeter 29.1-KW. hours, a difference of 5.1-KW hours, or 21.25%. This, at the average rate charged for current at the time, resulted in a loss of 9.16 cts. per night on this customer. It should be noted that the old meter had the advantage of being larger and had been thoroughly cleaned just before the test was made. The above test resulted in the purchase and installation of Westinghouse primary wattmeters. During the year 1899, when the old meters and transformers were in use, the station output was as follows:

	January.	July.	Year.
KW. hrs. generated	36483	22376	379112
KW. hrs. sold	13945	5888	118992
Per cent. sold	36.8	26.3	31.4
KW. hrs. generated for 1-KW. hr. sold	2.5	3.89	3.19

The above indicates that for the year 1899 3.09-KW. hrs. were generated for every 1-KW. hr. paid for, or, in other words, only 31.4% of the generated current was paid for, the remainder being lost by the old transformers and inaccurate meters.

A revenue of $21,375 was received for the 118992-KW. hrs. sold during this year, making an average price of 17.97 cts. per KW. hr.

The operating expenses of the generating station during the same year, including all labor and material, interest on bonds, taxes, cost of collections, insurance, free lamp renewals, advertising and general expenses were $14,406.25, making an average cost of approximately 3.8 cts. per KW. hr. generated, or 12.15 cts. per KW. hr. sold, leaving an average profit per KW. hr. sold at 5.82 cts.

It was decided to substitute a few large transformers having the same aggregate capacity as the 353 smaller ones, and to use short secondary distributing systems. By this means current was furnished to a greater number of customers, and the core loss in the transformers was reduced by 22,500 watts. In other words, the capacity of the generating station was increased by an amount equal to the installation of a 22½ KW. generator without any additional expense whatever for generating plant.

The old meters were replaced by Westinghouse round pattern wattmeters during the months of April, May and June, 1900. A test of the new meters and transformers was made in July, 1900, to compare with the test made on old meters and transformers in July, 1899. The following is the result:

	July, 1899.	July, 1900.
KW. hrs., generated	22,376	19,015
KW. hrs., sold	5,888	8,589

In July, 1900, a twenty-four hour service was furnished in place of the twelve-hour service of the previous year, but notwithstanding this, and the fact that additional customers had been secured during the year, the station output decreased for July by 3,361 hrs. With the new meters and transformers the company gave twenty-four hours' service during July, 1900, with a generated amount of 3,361 KW. hrs. (15% less than with the old meters and transformers), and at the same time received payment on 2,701 KW. hrs. or 46% more than with the old meters and transformers with a 12-hour service. This resulted in a decreased cost in coal for the month of $53.77, with an increased revenue of $465.19, or a net gain for the month of $518.96.

Below is given a comparative statement of the results obtained for the years 1899 and 1901.

	1899.	1901.
Total KW. hrs. generated	379,112	650,570
Total KW. hrs., sold	118,992	427,567
KW. hrs. generated to 1 KW. hr. sold.	3.19	1.52
Per cent. of generated current sold.	31.6	65.7
Total cost of current generated	$14,406	$27,610
Cost per KW. hr., generated	3.8 cts.	4.24 cts.
Cost per KW. hr. sold	12.15 cts.	6.49 cts.
Received for current generated	$21,375	$58,534
Number of customers	406	803
Average price received per KW.hr.	17.97 cts.	13.69 cts.
Average profit received per KW. hr.	5.82 cts.	7.20 cts.

The increased cost per KW. hr. for generating current in 1901 was due to an increase in the cost of coal and supplies.

The changes in meters and transformers increased the per cent. in 1901, and reduced the cost of the current sold from 12.15 cts. per KW. hr. in 1899, to 6.49 cts. in 1901. The average net profit per KW. hr. sold increased from 5.82 cts. in 1899 to 7.2 cts. in 1901, although the average price charged to customers had been reduced from 17.97 cts. in 1899 to 13.69 cts. per KW. hr. in 1901.

Customers were pleased with the reduced price and the accuracy of the meters, and their number increased from 406 in 1899 to 803 in 1901. This additional business necessitated an increase in generating capacity from 275 KW. to 400 KW.

In 1902 (23 months after installation) fifty of the new round pattern wattmeters were tested to ascertain their accuracy. Out of the 50 meters tested it was found that 49 had not deviated from the original calibration, that is, 2% plus or minus from 2% of full load to 50% overload. The other meter was found to run 4% fast. All meters operated on the baby filament by hylo lamps and none of them crept.

It is a curious fact that in purchasing boilers, steam engine and dynamos, great weight is laid on the matter of efficiency (which cannot vary but a few per cent. in the most efficient and inefficient dynamos), nevertheless, meters and transformers are purchased almost entirely on price, without regard to their efficiency.

TEST OF A HYDRAULIC ELEVATOR SYSTEM.*

By Reginald Pelham Bolton,† M. Am. Soc. M. E.

The contractors for the installation of 33 hydraulic elevators in the new department store of R. H. Macy & Co. gave a guarantee that the cost of fuel for its operation should not exceed 6 cts. per mile of car travel, coupling with this the stipulation that the water should be pumped by 3-throw crank and flywheel compound pumping engines, and that the boiler used should afford an evaporation of 10 lbs. of water per lb. of coal, and, finally, that the coal to be used should not exceed in cost $4 per ton. In letting contracts for pumps and boilers these conditions were followed, and guarantees exacted from the respective manufacturers. In the case of the pumps, a guarantee of steam consumption not exceeding 25 lbs. of steam per indicated horse-power was procured, and the boilers were guaranteed to afford an efficiency of 70%.

On March 15, 1903, the writer conducted a test of the combined apparatus, which, being carried out without any of the interferences which have been encountered in other tests of elevators, with a complete elimination of other apparatus, and at a time when the uninterrupted use of the necessary cars was at disposal, is of so complete, as well as satisfactory, a nature as to warrant the attention of the members of the Society.

ELEVATORS.—The elevators are large passenger cars of a full carrying capacity of 3,000 lbs., at a speed of 300 ft. per minute, operating from the basement floor to the 8th, 9th and 10th floor levels. They were constructed by the McAdams & Cartwright Elevator Co., of New York, and are provided with that company's hand-lever controls, are counterweighted to 650 lbs. unbalanced weight, and are provided with slack chains counterweighting the cables, which chains are attached to the car and the counterweight, giving a very accurate average weight of rope. They are operated by vertical hydraulic cylinders 15 ins. diameter, geared 4 to 1, and provided with pilot valves using two gallons of water to each complete reversal. The working pressure is 140 lbs. per sq. in.

Those selected for the test are known as Nos. 1, 2, 3 and 4, being a bank of passenger cars in the southeast portion of the building, having a round-trip travel of 292.5 ft. net per car, and Nos. 5 to 10, inclusive, being the passenger bank on the west end of the store, having a round-trip travel of 324.5 ft. net per car. Each car was loaded with a weighted live load of 1,000 lbs. inclusive of the operator, which was taken to represent an average load in cars of their proportions, and afforded a rate of down-travel uniform with that of the up-run. These elevators were selected as being those representing the average distance of cylinders from the pressure drums, so that the frictional hydraulic resistance is representative of average working conditions of the whole plant.

The cars were run on a schedule from bottom to top of travel and at such a number of trips as to reach as nearly as practicable a total travel of 30 miles per hour, which travel utilized the full and reasonably regular capacity of one of the two main pumps, which is the normal condition of the regular service of the building.

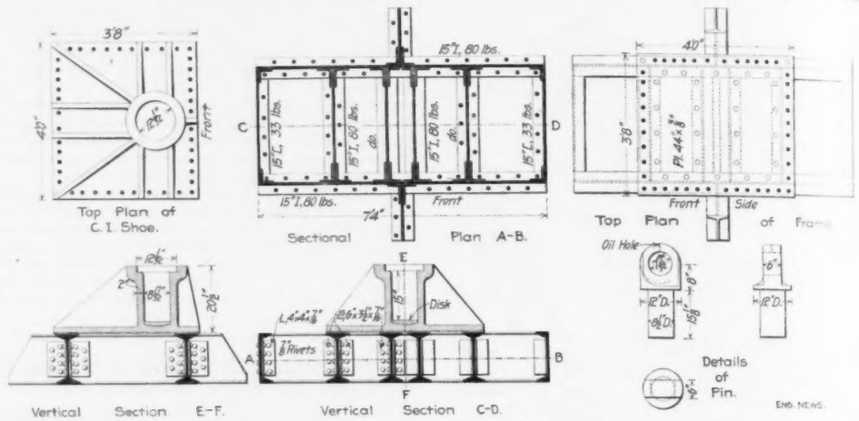

FIG. 10. DETAILS OF PIVOT CASTING AND SUPPORTING FRAME FOR DERRICK BOOM.

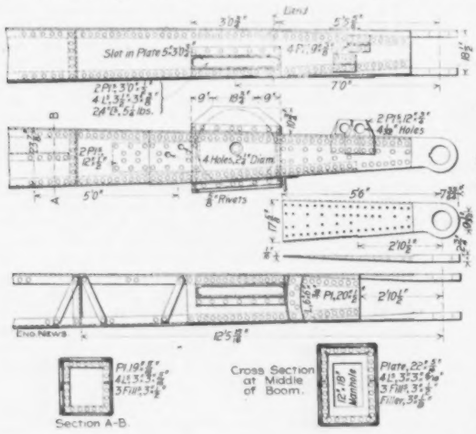

Fig. 11. Details of Boom Construction at Peak.

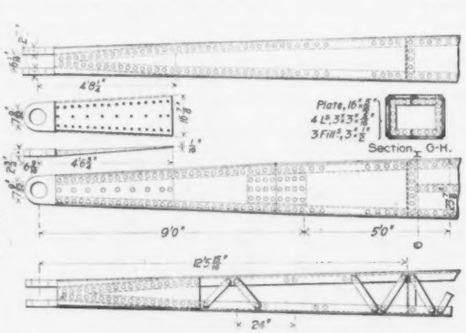

Fig. 12. Details of Boom Construction at Foot.

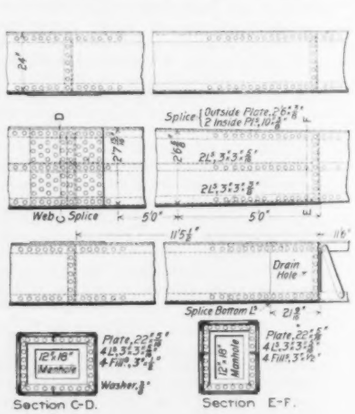

Fig. 13. Details of Section of Boom Near Middle, Showing Cross-Sections and Splices.

PUMPS.—The pumps are two in number, and are duplicates. They are the high-duty type manufactured by the Laidlaw-Dunn-Gordon Co., of Cincinnati, O., having a horizontal high-pressure cylinder 22½ ins. diameter, set between two low-pressure cylinders, each 28 ins. diameter, all 24-in. stroke, each operating a crank on the crank-shaft by rocking levers, and connected to three water pumps, each 14¾ ins. diameter by 24-in. stroke. During the trial the pumps were interchanged so that the result shows the average of their respective conditions. This was somewhat to their disadvantage, as No. 2 had a defective water valve.

The steam cylinders have Corliss valves, and the high-pressure steam supply is automatically controlled by the rising pressure in the pressure drums. There is a reheater between the high-pressure exhaust and low-pressure intake, the steam for which is charged in as part of the work, its condensation being run to waste during the trial. The low-pressure cylinders exhaust into the general exhaust system, which, during winter, is taken up entirely in house-heating work, but at the time of the trial was freely exhausted to the atmosphere through the 24-in. exhaust main about 380 ft. in length. Indicator cards were taken at regular intervals of 15 mins.

BOILER.—The boiler was of the water-tube type, with forged steel headers, constructed by the Babcock & Wilcox Co., of New York, and is of 293 rated horse-power. It

separate blower-nozzle was connected by a hose, and being placed in a tub of water, the steam condensed by its use for a given time was weighed.

ARRANGEMENT FOR TESTS.—The arrangements for the tests were laid down beforehand by the writer, and the rather numerous observers assigned to their duties, in a memorandum to which the representatives of all interested parties agreed, and in which the results to be sought were also stated. A preliminary run was also made on March 11, for two hours, in order to ascertain

*Abstract of a paper presented at the Saratoga meeting of the American Society of Mechanical Engineers, June 23-26, 1903.

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that all apparatus was in order, and to accustom the observers to their duties.

The general arrangements for the test comprised a separate feed pump supplying the boiler under test, the pump being supplied with steam from another source, and being supplied with water weighed in the usual manner. The feed was passed through a superheater or economizer on Kieley & Mueller's system, which consists of a single large pipe extending through the upper part of the smoke breeching. The feed was confined entirely to the boiler under test.

The steam from the boiler was conducted by a separate supply main only to the pump under operation. This main was dripped at its end, and a drip was also led from a Kieley steam separator placed over the stop-valve of each of the pumps. These drips were provided with separate bucket-traps discharging through a cooling coil into a tub on a weighing scale. The pump was charged with all the feed-water pumped to the boiler, less the amount of drips thus weighed back. Steam was tested for contained moisture at the boiler outlet.

The fuel used was an excellent grade of anthracite of buckwheat size, commonly known as No. 2, and cost, delivered into the bunker, $2.55 per gross ton of 2,240 lbs.

The test, as it related to the boiler, was conducted under the conditions established by this Society, the start and stop being made on the "alternate" method.

RESULTS OF TEST.—The observations recorded are shown in accompanying tabulation.

Summary of Readings Taken During Test of Elevators, Pump, Boiler and Furnace System at R. H. Macy & Co.'s Building, New York City, March 15, 1903.

Time.	Feet traveled by cars per hour.	Pump revolutions per hour (52.758 gallons per revolution.)	Net steam to pump, lbs.	Water to boiler per hour, lbs.	Coal consumed, lbs.	Ash.	Combustible.
9.30	165,982.5	3,630	6,651.5	6,778	.....	.....	.....
10.30	161,490.0	3,570	7,507.5	6,628	.....	.....	.....
11.30	161,586.0	3,218	7,277.0	7,613	.....	.....	.....
12.30	166,357.5	3,655	8,285.0	8,478	.....	.....	.....
1.30	167,139.0	3,645	6,453.5	6,612	4,691	567	4,023.61
2.30	164,991.0	3,590	7,145.5	7,290	.....	.....	.....
3.30	168,108.0	3,715	7,875.0	7,977	.....	.....	.....
4.30	164,602.5	3,518	6,844.0	7,037	.....	.....	.....
5.30	167,427.0	3,630	6,707.5	6,886	.....	.....	.....
6.30	168,400.5	3,633	7,874.0	8,043	4,749	467	4,180.37
Totals	1,656,084.0	35,824	72,620.5	74,342	9,440	1,034	8,203.98
Averages	165,608.4	3,582.4	7,262.05	7,434.2	944	103.4	820.39

Average flue temperature	413.55 degrees Fahr.
" feed-water temperature	75.18 degrees Fahr.
" steam pressure	132.2 lbs.
" pressure in ash-pit	.60 ins.
" draft in furnace	.19 "
" draft in flue (outside damper)	.40 "
" draft in flue (inside damper)	.225 "
B. T. U. per lb. coal	13,138
Moisture in coal	2.14 per cent.
Moisture in steam	.22 per cent.
Steam used in jets per hour	565.8 lbs.

The net results demonstrated the following facts:

Per car mile, fuel	32.32 lbs.
" " " steam	321.5 "
" " " water pumped	6,025. gals.
Live load actually lifted, per car mile	2,640,000 ft.-lbs.
Live load actually traveled, per car mile	5,280,000 "
Live load lifted per lb. of fuel	813,700 "

Pump.

Steam per indicated horse-power per hour	24.717 lbs.
Steam per water horse-power per hour	29.094 "
Water pumped per lb. of fuel	186.39 gals.

Piping.

Losses by condensation, per cent. of steam delivered from the boiler	2.36

Boiler.

Steam quality contained moisture of 1%	.22
Direct evaporation per lb. of coal, from feed at average of 75.18° F.	8.04 lbs.
Evaporation from and at 212° F., per lb. dry coal	9.56 "
Evaporation from and at 212° F., per lb. of combustible material	10.77 "

Grate System.

Fuel burned per sq. ft. per hour	15.86 lbs.
Steam used to operate blowers per hour	565.8 "
Equivalent coal at evaporation of 8.04	70. "

Coal.

Thermal value. Heat units	13,138
Moisture, per cent. of total weight	2.14
Ash and clinker, per cent. of total weight	10.95

From the above are worked out the following results of efficiency of each part of the apparatus in terms of the heat units contained in the fuel.

Efficiencies.

Coal, per cent. of perfect combustibility	86.91
Furnace, per cent. of heat received and liberated under the boiler	92.59
Boiler, per cent. of heat liberated, absorbed and delivered as steam, or efficiency	70.27
Piping, per cent. of heat received from the boiler and delivered to the cylinder	97.69
Pump cylinder, per cent. of heat received and turned into mechanical work	8.647
Pumping engine, per cent. of heat in piston work turned into water pumped	84.95
Elevator system, per cent. of work received in water pumped, represented by	
(1) The average live load raised	15.61
(2) The maximum live load raised	46.83

As the operation of the system involves the lifting of a greater weight than the load lifted in order to return the said load to the ground, which process is a part of the desired results, it is proper to state the effective results of the system in terms of the above loads traveled, when the respective efficiencies of the elevator system as stated above are doubled; or,

(1) The average live load traveled	31.22
(2) The maximum live load traveled	93.66

Efficiency of the Combined System of Apparatus, Furnace to Load.

Per cent. of heat in the fuel represented by the average live load traveled	1.6
The same by the maximum traveled	4.8

THE UNION ENGINEERING BUILDING.

A formal organization of the Joint Committee representing the various bodies which have taken action with respect to the gift of one million dollars by Mr. Andrew Carnegie for a Union Building, was effected on the evening of June 18. The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Engineers' Club have taken final action and appointed their representatives upon a Joint Committee for accepting the gift. The American Institute of Mining Engineers has likewise taken action in so far as its rules permit. Its Council has appointed representatives subject to changes in the rules of the organization which have been proposed by the Council for adoption at the next general meeting At the present time a letter ballot for ascertaining the attitude of the members is being taken which shows an overwhelming majority in favor of the plans proposed by the Council.

The American Society of Civil Engineers at its recent meeting in Asheville referred the matter to its Board of Directors for recommendation, and directed that the matter be then presented to the members of the Society for letter ballot.

At the meeting on the 18th instant, the following were announced as representatives of the several bodies upon the Joint Committee:

American Institute of Mechanical Engineers: James M. Dodge, F. R. Hutton, Charles Wallace Hunt.

American Institute of Electrical Engineers: Charles F. Scott, B. J. Arnold, S. S. Wheeler.

American Institute of Mining Engineers: A. R. Ledoux, Charles Kirchoff, Timothy Dwight.

Engineers' Club: John C. Kafer, W. H. Fletcher, W. A. Redding.

Representatives of the American Society of Civil Engineers are requested to meet with the Joint Committee and take part in deliberations with regard to the plans to be adopted. The representatives who have served upon the Conference Committee are Alfred Noble, W. J. Wilgus, George H. Pegram.

The Joint Committee was organized by the election of the following officers:

Chairman, Charles F. Scott; Secretary, Professor F. R. Hutton. The Chairman was directed to indicate to Mr. Carnegie the acceptance of his gift by the Joint Committee representing the several organizations.

The Joint Committee placed the immediate work of developing plans upon an Executive Committee of five, consisting of one member from each of the five organizations named in Mr. Carnegie's letter as follows:

American Society of Civil Engineers: Mr. Alfred Noble.

American Society of Mechanical Engineers: Prof F. R. Hutton.

American Institute of Mining Engineers: Mr. A. R. Ledoux.

American Institute of Electrical Engineers: Mr. Charles F. Scott.

Engineers' Club: Mr. W. M. Fletcher.

The Executive Committee met on May 19 and organized by the election of Charles F. Scott, Chairman; and F. R. Hutton, Secretary. The Committee laid out certain work to be undertaken by its several members, and will have meetings from time to time during the summer.

The following cablegram has been sent to Mr. Carnegie:

"Andrew Carnegie, Skibo Castle.

"Joint Committee four organizations formally accepts generous gift Union Building. Executive Committee in session sends greeting and reports progress.

Scott."

NOTES FROM THE ENGINEERING SCHOOLS.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—A graduate school of engineering research will be established immediately after the opening of the next academic year, Oct. 7, 1903. It is intended to provide facilities for a small number of advanced students.

Courses will be offered by the Departments of Civil, Mechanical, Mining, Electrical, Chemical, and Sanitary Engineering and Naval Architecture. The maximum charge for instruction will be $250 for the year. Four fellowships of $500 each will be available, and the holders will be exempt from tuition fees.

The degree of Doctor of Engineering will be conferred for satisfactory resident work occupying not less than two years.

CORNELL UNIVERSITY.—The annual report of President Schurman, just issued, shows that the students in Mechanical and Electrical Engineering outnumber those of any other department. Out of 3,018 students enrolled during the college year from September to June, 890 were in the mechanical and electrical engineering department and 253 in the civil engineering department, while the undergraduates in the College of Arts and Sciences numbered 795.

The Ithaca typhoid epidemic caused the illness of about 300 students and the death of 29, and during February and March about one-third of the student body left Ithaca on account of the epidemic. The water supply of the University itself, which also supplies the professors' houses on the campus, Sage college and the fraternity houses was at no time shown to be contaminated. Nevertheless plans have been made for the installation of a complete filtration plant for this supply, and the money for it has been furnished by Mr. Andrew Carnegie.

RECENT PRACTICE IN FORCING, SHRINKING, DRIVING AND RUNNING FITS, AND LIMITS FOR LIMIT GAGES.*

By Stanley H. Moore,† Jun. Am. Soc. M. E.

The crude or working material which is the basis of this investigation is that which has been published during the last few years in the leading technical periodicals. For the convenience of treatment the matter was divided into the following classes: Forcing Fits, Forcing Fit Pressures, Shrinking Fits, Driving Fits, Running Fits, and Limits for Limit Gages. In order, in each individual case, to discover and ascertain the nature of a probable law, the data were transferred to rectangular co-ordinates where the curve was plotted, the ordinates representing the diameters in inches; the abscisses the allowances. The result of this first plotting was the deduction of an empirical formula for each individual case. For the purpose of comparison the curve for this formula was transferred to what was termed the Typical Diagram. In these typical diagrams such curves as were obviously wild and wide of the mark were omitted.

The next step, and one deemed necessary for the compilation of an accurate table to fit allowances, was the selection or construction—from the typical diagrams—of what were termed Representative Curves which would clearly indicate good practice. The choice of these representative curves, being largely a matter of judgment, is open to criticism; however, the selections were made with a view to securing a simple formula that would at once embody the essential features of good practice and omit nothing of importance. A careful examination of these curves, with due consideration as to the manner in which they were obtained, will, we think, justify the selection.

*A paper read at the Saratoga meeting of the American Society of Mechanical Engineers.

†Director Manual Training Department, Manual Training High School, Kansas City, Mo.

FORCING FITS.

For the purpose of discussion, forcing fits may be defined as those machinery fits which require the use of some form of press, generally hydrostatic, to complete the assembling operation.

A study of the various curves of the typical diagram for forcing fits led to the selection of a Representative Curve whose formula contained a constant. This was

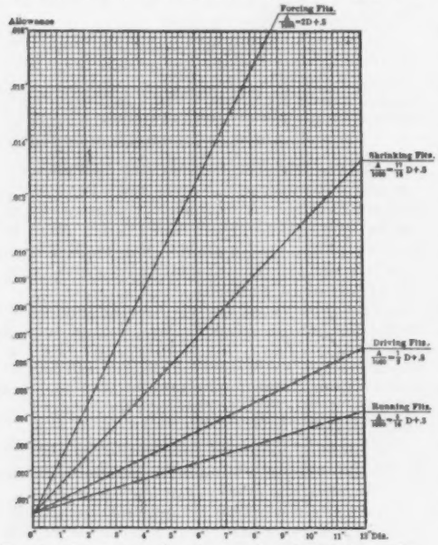

Fig. 1. Representative Curves for the Various Fits.

considered desirable, especially on account of its influence on the smaller sizes. The formula selected for the Representative Curve for forcing fits was:

$$A = 2D + .5;$$

A = allowance in thousandths of an inch;
D = diameter of the plugs in inches.

Regarding the assembling process, or the manipulation of forcing fits, we find the following governing conditions: 1. The Allowance. This should never be so great as to prevent the stress from coming well within the elastic limit or crushing strength of the materials employed. 2. Surfaces. In general we may say regarding the surfaces for this kind of fitting, that the best results are obtained when both surfaces are ground to fit gages. The conditions, in some instances, render this impracticable; however, the surfaces of the pieces to be assembled should be as smooth as it is practicable to make them. 3. The Lubrication. Linseed oil makes an excellent lubricant for assembling forcing fits. 4. The Alinement. It is important to start the plug accurately; so important is this that to secure an accurate alinement some engineers resort to the use of two diameters—each half the length of the fit—differing by but a few thousandths of an inch. The additional advantage of having to force the plug through but half the length of the fit, it is claimed, greatly reduces the maximum forcing fit pressure.

FORCING FIT PRESSURES.—Here the fixed conditions are generally the following: The materials employed; the nominal diameter; the length of the fit, and the thickness of the hub. With these conditions the pressure necessary to assemble a given forcing fit will vary, Mr.

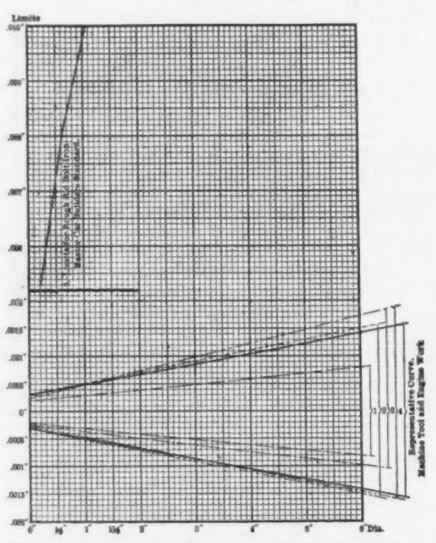

Fig. 3. Typical and Representative Limits Diagram.

Kelley concludes after his experience with about 800 forcing fits on regular engine work:

(1) Directly as the area of the surface of the fit for a given diameter; (2) Directly as the allowance—the difference in diameter between the plug and the bore; (3) As a function of the radial thickness of the hub; (4) As the material employed and the nature of the machined surfaces. The investigation for a pressure curve was undertaken on this basis—on the assumption that these conclusions are correct. After considerable work a simple equation for a Representative Pressure Curve was established. The equation gave essentially the results obtained by the use of Mr. Kelley's experimentally derived curve, and while possessing the advantage of mathematical deduction, it had the additional advantage of conforming to experience and becomes, therefore, thoroughly practical in its application.

The curve, an hyperbola whose equation is

$$P F = \frac{500}{D^{1.08}},$$

where P F is the pressure factor, and D the nominal diameter of the fit, assumes the hub to be twice the diameter of the plug, the materials employed to be machinery steel plugs and cast-iron hubs, and the machined surfaces to be practically true and free from tool marks. Should the hub diameter exceed twice that of the plug, the pressure, according to condition (3), will be somewhat greater—the amount being obtained by the construction of another hyperbola. Should the materials employed be other than those which the curve assumes, the pressure, according to condition (4), will again vary, necessitating the determination of another value of P F. . . . The few values obtained from the meager data relative to this particular point, seemed to indicate that a new value of P F might be obtained by multiplying P F directly by the ratio existing between the average value of the crushing strengths of the two new materials and the average value of the crushing strength of cast-iron and machinery steel. Moreover, the investigation disclosed the problem to be far too complicated to admit of any so simple a solution. The dearth of particular values and the incompleteness of the experiments leading to the above indication, were such as to influence the author to say that the statement is of no practical value. However, it may be well to state that the problem was first attacked on the assumption that a solution might be had from a comparison of the moduli of elasticity of the materials. This position was rendered untenable: First, because in materials such as cast-iron which have no well-defined elastic limit, the modulus decreases from a maximum near the beginning of the test; second, as some permanent deformation of the bore and plug generally results as a consequence of the assembling, the elastic limit of the material is obviously passed—this furnished a clew for attacking the problem with reference to the crushing strength. Then again the investigation proceeded with a treatment of the hub as a thick hollow cylinder under tension; were this assumption correct, the formulas of Professors Barlow and Merriman should be applicable, and the tension on every concentric layer caused by the internal pressure, vary inversely as the square of its distance from the center. This position is faulty in that cast-iron is not homogeneous in texture, is not incompressible, and when used for the material of cylinders of hydraulic presses the thicknesses which obtain are such that the stresses calculated by these formulas would postulate the use of steel to render them reasonably safe. This latter may not be a parallel case, as hydraulic cylinders are usually solid at one end.

In passing the author concludes that the influence which the use of different materials will have on the pressure may only be satisfactorily determined by experiment.

The tabulated values of P F from this curve will prove the more convenient for ready reference. The method of using the curve is as follows, however: Select the nominal diameter of the fit and follow its ordinate up to the curve; from this intersection follow horizontally to the left and read P F the pressure factor. The equation for the pressure is

$$\text{Pressure in tons} = \frac{\text{Area of surface of fit} \times \text{Difference in diameter between plug and bore}}{2}$$

The result will be the pressure in tons required to force the plug home. The foreman may thus also easily determine whether or not his press is of sufficient capacity for the work in hand.

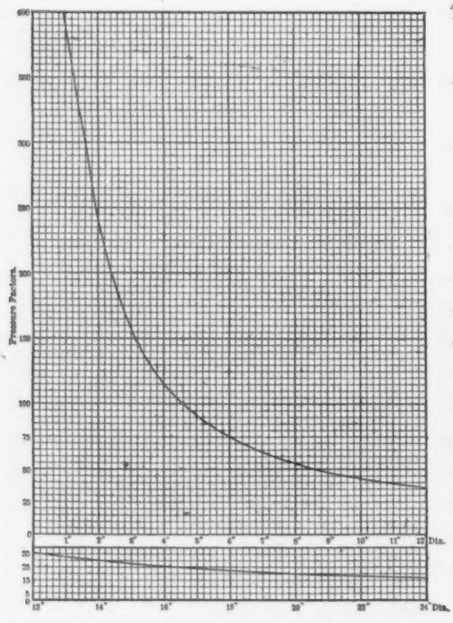

Fig. 2. Forcing Fits—Pressure Factor Curve.

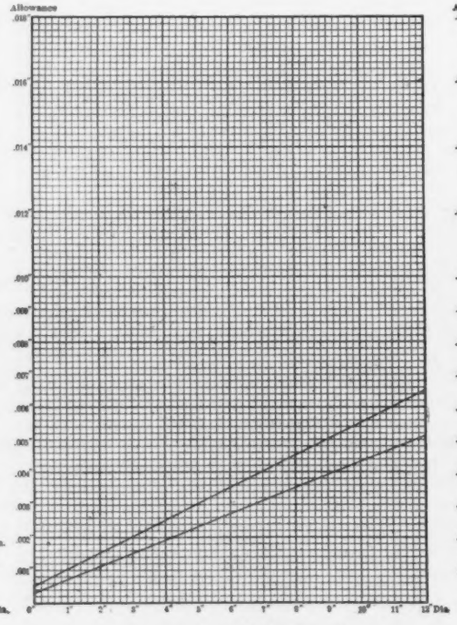

Fig. 7. Typical Driving Fit Diagram.

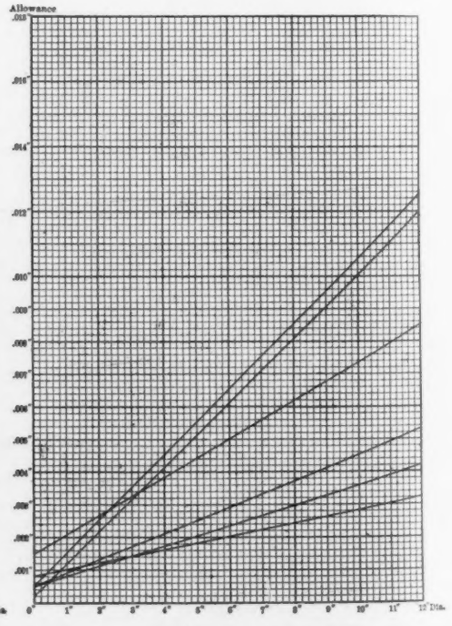

Fig. 8. Typical Running Fit Diagram.

SHRINKING FITS.

The Representative Curve chosen for shrinking fits was the one whose equation gave allowances which agreed with the standard adopted by the American Railway Master Mechanics' Association for locomotive wheel-center and tire gages. The agreement is identical to the thousandth decimal place, this being the extent to which their standard is carried. The equation is

$$A = {}^{17}/_{16}\,D + .5;$$

A = allowance in thousandths of an inch.

The allowances obtained by the use of this formula while

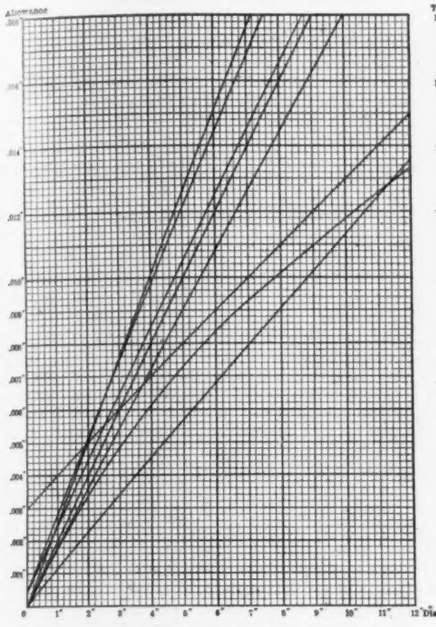

Fig. 4. Typical Forcing Fit Diagram.

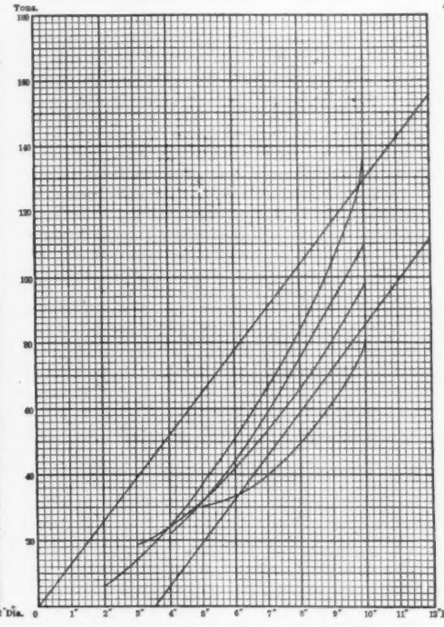

Fig. 5. Typical Forcing Fit Pressure Diagram.

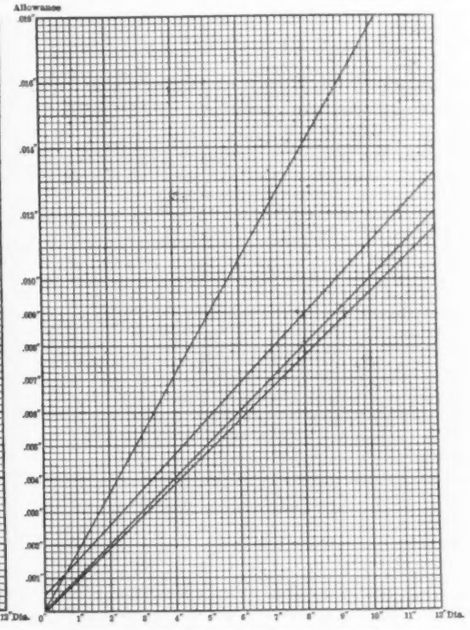

Fig. 6. Typical Shrinking Fit Diagram.

not excessive are sufficient to insure a tight fit, thus avoiding the danger of excessive shrinkage stresses, oftimes deemed negligible, which are always additional to those incident to actual service. Taking the modulus of elasticity of steel at 30,000,000 the stress caused by this amount of shrinkage would be about 33,000 lbs. per sq. in., which is well within the elastic limit of machinery steel.

Considering this class of fitting with a view to obtaining the greatest resistance to tension and torsion, we discover that shrinkage fits are far superior to forcing fits, they being, under like conditions, as Professor Wetmore has shown, uniformly about three times as tight both in tension and torsion. Experiments seem to indicate that in this class of fits the resistance to torsion increases more rapidly with the diameter than does the resistance to tension.

In the manipulation, good practice maintains that a piece should rarely be heated hotter than a very dull red heat —about 800° F.—and under no consideration to the scaling point. This temperature of necessity limits the fit allowance to something less than 700° × .00000556 = .003892 per unit diameter for cast iron. It will be found upon an examination of the formula that the heating to this temperature is ample for the allowances given by the Representative Curve.

Regarding the process, better results will be obtained if the entire piece be heated slowly and uniformly instead of trying to hasten matters by "blazing up" through the bore. The latter practice is sometimes negative in its results; in cases permanently reducing the bore diameter instead of increasing it as desired, the expansion being inward instead of outward. In general, it may be said that this class of fitting requires more skill and experience in its manipulation than does force fitting. Not only in the heating and assembling is this skill and experience necessary but in the cooling as well.

DRIVING FITS.

Very little data could be secured for this class of fitting, the inference being that this method of assembling is about obsolete. A field may still exist for such small work as the assembling of the smaller pins and cranks of valve gearing, where the formula for the Representative Curve might be used to advantage when the fit is made with an arbor press or some kindred method. This formula might also be used for some classes of tight-keyed fits; however, the practice of driving home a plug by blows is too crude to be used except where no other method is available. Our Representative formula for this class of fitting is

$$A = {}^{1}/_{16}\,D + .5;$$

A = allowance in thousandths of an inch.

RUNNING FITS.

A running fit is designed to allow the surfaces in contact to move or revolve freely over each other. The more nearly the surfaces in contact approach perfection the better will be the fit; however, there should be a sufficient difference in diameter to admit of motion and lubrication. The difference in diameter to be allowed in any given fit depends upon the following conditions: The nature of the machined surfaces; the kind of metals in contact; the length of the fit and its diameter. The perfection of the fit, depending largely as it does upon the surfaces in contact, renders it imperative that they be smooth and true. When possible, on the smaller sizes, bored holes should always be reamed, as this not only insures a standard size but finishes the hole comparatively smooth and true.

The formula selected for the Representative Curve for running fits on machine tool, engine work and kindred practice was

$$A = {}^{5}/_{16}\,D + .5;$$

A = allowance in thousandths of an inch.

It will be remembered, of course, that in order to obtain the bore diameter the allowance should be added to the diameter of the shaft. For obvious reasons it was considered desirable that this formula contain a constant; it assumes the condition of the surfaces in contact to be similar to that obtained by the use of a reamer and the allowances will be found to fall slightly within the limits given by the Representative Curve on the limits diagram.

For those who may not know, in passing, it might be well to give a few cautionary paragraphs regarding the production of satisfactory running fits. Regarding the truth and accuracy of bored holes, practice indicates that the best results are obtained with a very light cut, a high speed and slow feed. In light chuck work there is a tendency in tightening the chuck jaws to distort the piece, and it may be necessary in some instances to partly relieve the pressure for the light finishing cut. The most satisfactory results are obtained, in fitting, where limit gages are used; where no limit gages are to be had, in many instances it will be found advantageous to finish the bore first, as it is easier to fit the shaft to the hole than vice versa. When a fit is made, any tool marks left on either the shaft or the bore wear away rapidly and defeat the purpose of the work. Not only is their helical construction conducive to rapid wear, but it renders perfect lubrication almost impossible, as the grooves tend to lead the oil out of the bearing. It is desirable to have the surfaces in contact ground, as they then approach perfection; where this is not feasible they should be filed and polished. On good work a very few strokes of the file will suffice to remove the tool marks; little or no filing should be attempted after their removal, as the filing of cylindrical work is at its best a negative process where truth and accuracy are to be sought.

LIMITS FOR LIMIT GAGES.

Limit gages, as we are well aware, are used primarily as time savers; they avoid the waste of time in finishing parts unduly accurate, while still having them accurate enough to meet all the demands of interchangeable manufacture. The selection of the limits of variation for any given class of work requires experience and sound judgment. As it is clearly a matter of time-saving, the problem resolves itself into two phases—the accuracy and efficiency of the machine on the one hand, and the rapidity of production on the other. The largest limit of variation then that will produce the desired accuracy and efficiency in the machine, is the one to be selected. For this reason the selection of a Representative Curve of limits proves a hazardous undertaking for any but he who has to do with the production of the machine; however, the author ventures the curve plotted on the limits diagram as being suitable for machine tool, engine work and similar practice. In the manufacture of limit gages there are reasons why one of the sets should be made one-half the allowable variation larger than the nominal size, while the other set should be made just as much smaller. This, it is believed, is the practice of the best manufacturers, though in some of the data investigated such was not the case. The Representative formula

$$\frac{L}{2} = {}^{3}/_{16}\,D + .3$$

gives half the limit variation in thousandths of an inch, plus or minus as desired.

While the specific values obtained from the formulas, diagrams and table will prove, no doubt, of great value to many, they should be taken as a guide indicating the conditions which existed in the data which the author was able to procure. As it is impossible for one individual to secure and tabulate that amount of information from the thousands of progressive machine shops of this country, necessary to indicate the average American practice in this direction, the greatest value of this paper may be found in its discussion by those who know, and again in its indication of what may be done with similar masses of seemingly chaotic data.

Table of Tabulated Data Relative to Fits and Fitting.

(In order to place the results of this investigation in the most convenient form, that adequate for ready reference, the allowance values for each class of fits were calculated and tabulated under the following arrangement.)

Pressure Factors.	Nominal Diameter of Fit.	Forcing Fit Allowances.	Shrinking Fit Allowances.	Driving Fit Allowances.	Running Fit Allowances.	Limits for Limit Gages.
$P = \frac{300}{D^2}$		$A = \frac{17}{16}D + .5$	$A = \frac{17}{16}D + .5$	$A = \frac{1}{16}D + .5$	$A = \frac{5}{16}D + .5$	$\frac{1}{2}L = \frac{3}{16}D + .3$
				.0006	.00058	.00035 + or
				.0008	.00065	.00039 "
				.0009	.00073	.00044 "
391	1	.0025	.0016	.0010	.0008	.0005 "
319	1½	.0035	.0021	.0013	.0010	.0006 "
240	2	.0045	.0026	.0015	.0011	.0007 "
156	3	.0065	.0037	.0020	.0014	.0009 "
115	4	.0085	.0048	.0025	.0018	.0011 "
91	5	.0105	.0058	.0030	.0021	.0012 "
75	6	.0125	.0069	.0035	.0024	.0014 "
64	7	.0145	.0079	.0040	.0027	.0016 "
55	8	.0165	.0090	.0045	.0030	.0018 "
48.5	9	.0185	.0101	.0050	.0033	.0020 "
43	10	.0205	.0111	.0055	.0036	.0022 "
39	11	.0225	.0122	.0060	.0039	.0024 "
36	12	.0245	.0133	.0065	.0043	.0026 "
30.4	14	.0285	.0154	.0075	.0049	
28.4	16	.0325	.0175	.0085	.0055	
23.3	18	.0365	.0196	.0095	.0061	
20.8	20	.0405	.0218		.0068	
18.8	22	.0445	.0239		.0074	
17.2	24	.0485	.0260		.0080	
15.1	27	.0545	.0292		.0090	
13.5	30	.0605	.0324		.0099	
	38		.040			
	44		.047			
	50		.053			
	56		.060			
	62		.066			
	68		.070			

A glance at the Representative Curves of the various fits and their formulas reveals the allowances to bear the following relations to each other: 5, 5, 17, 32, starting with the curve for running fits.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

Municipal ownership of water-works in practically all the large cities of the United States bids fair to be the rule a few years hence. Memphis, Tenn., has just acquired the plant owned for some years past by the Artesian Water Co. This reduces to nine the cities of the United States of over 100,000 population whose water-works are still under private ownership. The nine cities, in order of their size in 1900, are: San Francisco, New Orleans, Indianapolis, Denver, New Haven, Paterson, St. Joseph, Omaha, and Scranton. Two of these, New Orleans and Omaha, are already committed to municipal ownership, and for years there has been a strong movement in that direction at San Francisco. Agitation to the same end was also very much in evidence at Indianapolis and Denver, a few years ago. The cities of 100,000 population or over numbered 38 in 1900, of which 29 now own their water-works. In the same year there were 97 cities with populations ranging from 100,000 to 30,000, and of those nearly 70 own water-works, while a number of others are making more or less rapid progress towards municipal ownership. Unless the tide turns, and there certainly is no indication of it, 20 to 25 years hence will show but few cities of 30,000 population supplied with water by private companies.

Why are changes to public ownership so common, and why are they so much more numerous in the case of water-works than in other classes of public utilities? The answer to both these questions is that a water supply is so essential to the general prosperity of a community, and so closely related to the comfort and health of every citizen, as to give rise to an even stronger feeling that its supply should not be entrusted to those whose primary object is profit. As an abstract proposition this cannot be successfully disputed. Arguments in plenty there are in support of the contention that a private water company, either through selfish interests, or by means of public regulation, can meet all the wants of a community as cheaply and as well as the community itself, but the public cannot often be convinced that ability and willingness will here go hand in hand. Aside from this lack of confidence there is a strong feeling, whether based on prejudice or reason, that private water companies take advantage of the fact that their customers are at their mercy, and treat them with scant courtesy, to say the least. The public generally has an exaggerated idea of the profits made by water companies and other public service corporations. Publicity of accounts would do much to rectify this belief, and this combined with proper public regulation of rates and profit would do far more. These two reforms, combined with more considerate treatment of customers by companies, might have stopped many a move for public ownership years ago, and while not so powerful now they are well worthy of more serious consideration than has yet been given to them by private companies.

Beneficial as municipal ownership may be, no one would object to having its progress checked somewhat by such methods as these. Many of our cities need other reforms quite as much as a change to municipal ownership of water-works, and in such cases amelioration of the evils of private ownership might leave the city free to enter upon other works for the benefit of its citizens.

The "Chicago Interocean," discussing the control of floods in the Mississippi and its tributaries, says:

> Any plan for the control of floods that does not involve the reforestation of the watersheds will fail. Storage basins or reservoirs are destined undoubtedly to play a great part in the general scheme of water supply and irrigation, but without the reforestation of watersheds and the forestation of the plains they will be wholly inadequate to the solution of the gravest problem before the country.

Admitting for the sake of argument, that this were true, the logical conclusion would be that floods must continue. The cultivated farms and fields of the Mississippi valley cannot be turned into forests. To do this would result in a greater loss than all the devastation due to floods. It may be said that the waste lands in the semi-arid regions might be planted to trees; but even if trees could be made to grow there, it would not at all solve the flood problem, for it is the rainfall in the humid region that is the chief cause of great floods. It was the precipitation on the farms and grain fields of Nebraska and Kansas and Iowa that caused the recent disastrous floods in the Missouri and in the rivers of Iowa, and the floods would have come just the same had the arid plains to the westward been covered with forests.

We are strong advocates of forest preservation and cultivation, but that work is worth while for its own sake, and has little to do with the problems of river control, as was admirably pointed out a short time ago by the New York Commission on flood prevention.

The published criticisms regarding the foresty work conducted by the College of Forestry of Cornell University led to the cutting off of the State appropriation for this work at the last session of the legislature. In the annual report of President Schurman of Cornell, just issued, this matter is reviewed, and an explanation is given of the course which has been followed. According to this it appears that when the University was placed by the State in charge of 30,000 acres of Adirondack timber lands, Dr. B. E. Fernow, Director of the College of Forestry, determined to replace the growth of hardwoods on the tract with a new growth of pine, spruce and other valuable soft woods. Under this plan from 500 to 800 acres have been cleared each year, and on the land thus cleared plantations of soft wood trees have been started.

This course, however, has roused great public opposition, as it has been strenuously maintained that the existing timber on the State lands should be preserved and not removed, even for the purpose of creating a new growth, since this latter will require a generation to really convert the land into forest again. A special Assembly committee which investigated this matter at the last session of the legislature presented a report in which they said:

> We deeply regret that our careful investigation of the experiment leaves us unable to approve of what has been done, and obliged to condemn both present and prospective results.
>
> The theory advocated is to obliterate the forest by cutting sections annually, and follow by replanting so that the new forest will produce marketable products in succession as the last portions of native trees are removed. In practice, however, the cutting must be accelerated and the planting retarded, so that even with favoring conditions this tract of forest will be extirpated in less than forty years with no chance for restoration within one hundred.
>
> As an excuse for the present unsatisfactory condition the statement is made in a recent report of the Cornell Forestry College that the tract given to them by the State was a poor one, that 'all the valuable soft woods had already been removed by the lumbermen, and only hardwoods, mostly rotten, remain.' Upon investigating this matter the committee was informed that the forester of the University, after inspecting personally the several lands offered some of which were well timbered with virgin forests, selected this particular tract.

President Schurman in his report reviews the action of the State authorities and says that "the University stands by its expert," and that since the State appropriation has been cut off, the College of Forestry will be discontinued.

It is greatly to be regretted that the first College of Forestry in the United States should come to so ignominious an end; and looking at the matter from a wholly unprejudiced point of view, the college authorities cannot be held blameless in the matter. Very likely the plan adopted by Director Fernow was the correct one from a strictly commercial point of view; but it was a serious mistake to undertake to manage the State lands from such a standpoint. Public opinion in New York values these State lands as a forest preserve and not as a means of revenue, present or prospective; and to attempt to run counter to this great body of public opinion was certain to result in disaster. Had the clearing and replanting been undertaken on a small scale, it would have been equally valuable for instruction to the students, and as an object lesson to the public in future years and no public opposition would have been aroused. It cannot be seriously maintained either that the removal of the hard wood forest and replanting with conifers was the only possible course to pursue. No reason appears why the mature trees might not have been gradually removed where necessary to permit the growth of younger specimens; and the whole tract might have been administered to preserve and perpetuate the growth of the more valuable species of hard woods, without clearing any considerable portion at all.

The most unfortunate part of the whole affair is that the persistent disregard of public opinion and the stubborn adherence to the course first laid down as if it were the only possible one to pursue has tended to bring "scientific forestry" into disrepute in New York. A few years ago the prospect seemed good that all the New York State lands might be placed under expert management, but it would now be difficult to muster a corporal's guard in the State legislature to favor such a course.

There is a certain tendency, in these days, to hold the Government responsible for waves of financial prosperity or depression. A contributor to a recent issue of the New York "Sun" goes a long step farther and attempts to place upon Government engineers the responsibility for the recent severe floods. We quote as follows:

> To the Editor of The Sun—Sir: The heartrending calamity in the Missouri Valley, the Brazos Valley a few years ago, the Mohawk Valley recently, and now in Georgia, all go to show that the Agricultural Department must be put in charge of our waterways so that single-span bridges may replace all "pier" bridges! The same reasons which impelled a transfer of the Weather Bureau will also compel a transfer of the Engineer Corps from the War Department to the Agricultural Department, for we must have single-span bridges instead of these "pier" bridges with their awful calamities.
>
> James Seldon Cowden.
>
> Washington, June 2.

After reading the above letter one is led to mildly suggest that the recent disastrous floods may be quite as directly traced to the Weather Bureau, and the Agricultural Department as to the "pier bridges" and the Corps of Engineers. The benefits from transforming our Captains and Colonels to Agricultural Engineers is therefore

not evident. Incidentally it is not without interest to note that the author of the above letter is one of the advocates of the "outlet" scheme for controlling the Mississippi River.

The idea that a great reduction in the air resistance of high-speed trains would result from putting a sharp beak or prow at the head is continually reappearing. We are told that the last new design for a high-speed steam locomotive "made in Germany" is to have a wind-splitting beak; and in Southern California Mr. H. E. Huntington is reported to be experimenting with steel "wind-hoods" for interurban electric cars, designed to run at 60 miles per hour.

Possibly with single cars or with very short trains a sharp prow at the front and rear might reduce the train resistance enough to be worth while. With trains of ordinary length, however, the air resistances at head and rear are so small a part of the total train resistance that the percentage these resistances could be reduced by any form of beak makes a gain too small to be discovered save by most painstaking investigations. It is not this class of improvements, therefore, that appeals to those who control the purse strings.

MACADAM AS A CORE FOR DAMS AND RESERVOIR EMBANKMENTS.

The essential qualities that a dam core wall should possess are: (1) durability; (2) stability; and (3) impermeability. It is also advantageous if the core be heavy, and its cost is a most important factor.

The relative merits and demerits of core walls of concrete and of puddle in earth dams have been pretty thoroughly discussed by engineers. We wish now to point out that there is another class of material available for such walls which lies midway between puddle and concrete as to cost and is slightly if at all inferior to concrete in the matter of permeability. We refer to broken stone and stone screenings (without cement) thoroughly rolled or rammed and puddled with water—in a word, macadam.

So far as we know, macadam has never been used as a core wall for permanent dams. If such instances exist, we should be very glad to hear concerning them. For temporary work, one of the editors of Engineering News some years ago built a small cofferdam in a quarry where it was necessary to divert a creek from the quarry site in the creek bed. Crushed stone and screenings were rammed and puddled between plank walls to form the cofferdam, clay not being available while the stone and screenings were right at hand. The results were satisfactory. In building a macadam core wall for a permanent dam, the use of a steam roller to consolidate the macadam would be advantageous. If the dam is too small to permit this, we have left two means by which to effect consolidation and filling of the voids: (1) ramming, and (2) puddling the screenings into the voids with water. Both should be used.

As stone comes from the crusher there is theoretically enough dust and fines to fill all voids if a perfect mixture were secured, under ramming carried to a sufficient degree. In practice, of course, a perfect mixture of fines with coarse so as to exactly fill all voids, is impossible without using an excess of fines. On a macadam road the 10-ton roller produces a large amount of additional fines by the pulverizing action of its wheels, unless the rock is extremely tough, so it often happens that no fines, aside from those made in the ordinary process of crushing, need be added to secure a perfectly impenetrable mass with voids not exceeding those in concrete. Ramming, however, will produce little or no additional stone dust. Hence it must be supplied either in the form of fine sand or earth by running a part of the medium sized product (½ to 1¼-in.) of the crusher through rolls.

As to the method of mixing and depositing macadam which is to be rammed, two ways are open for selection. The stone as it comes from the crusher may be mixed with 15 or 20% of stone dust (made by rollers or mills) in a concrete mixer or by hand, just as in making ordinary concrete, wet well with water and rammed to place. The other method of handling would be to follow the practice in making macadam, except as to using rollers; and in that case the coarse, clean stone would be deposited in 4-in. layers, thoroughly rammed dry, then a layer of screenings and fine stone dust would be spread with shovels to a depth of 1 or 1½ ins. and washed into the voids below with water, after which ramming would again be done. Either method will secure a compact mass. Of course, all this means labor, and ramming would, in a measure, offset the cost of the cement required for a concrete wall. Where the dam is large enough to permit the use of a steam roller, however, the work of consolidation will be done by steam instead of by human muscle, and here it seems to us the use of macadam dam cores would be most advantageous. It does not follow, however, that the dam need be of great height. In reservoir embankments, for example, it might be possible to keep the roller continually circulating packing the successive layers of macadam as fast as spread.

We shall doubtless hear the objection raised that as ample precedent exists for the construction of sound and safe dams with either concrete or puddle core walls, there is no need of experimenting with macadam cores, namely, to save the purchase of a little cement, or the hauling of clay for puddle. It may very possibly be true that the macadam core would possess no advantage over the accepted types of structure in ordinary structures, and yet it may be of great service to the engineer in other places.

Engineers are called on to build dams, it must be remembered, in all sorts of places, wholly without regard to the proximity of suitable materials. In building irrigation reservoirs in the West, for example, the engineer is frequently forced to use some such device as a rock-filled dam with a wooden skin on the water face, or a braced steel structure. Masonry or concrete dams would oftener be used in place of such structures were it not for the high cost of delivering the cement, which in some cases brings the cost to $6 or $8 a barrel for Portland cement delivered at the dam site. A rock-filled dam being made of large stones without any filling between them obviously requires a wood or a steel facing or core to make it impervious, and such a facing will require some expense for maintenance and, ultimately, renewal.

In canvassing the permanence and the watertightness of such a macadam core, it may be of interest to recall that macadam rolled or rammed to place and puddled with fine stone dust is really a concrete, and may have very considerable strength. Although not generally known, it is nevertheless a fact that unburned limestone dust mixed with water and slightly compressed hardens almost as if it were a cement. Dust of other stone also possesses this settling action to a greater or less degree. Felsite, for example, shows an exceedingly high cementation value according to the Massachusetts Highway Commission experiments. Even quartzite dust ranks with some of the limestones in cementing value.

As yet we do not know why fine stone dust sets or "cements" when subject to pressure in the presence of water. It may be that the water and the pressure act to exclude and force out the film of air that normally surrounds each particle of solid matter, and possibly the water so lubricates the particles that they move more readily under pressure. In any case the dust particles appear to be brought so close together that the molecular force of adhesion comes into play. Chemical action, analogous to the setting of cement, may possibly take place in the dust of rocks, although it surely does not in the case of quartz dust.

Whatever the cause may be, the indisputable fact is that rock dust does set, under suitable conditions, and it is immaterial whether it possesses this strength in virtue of physical or of chemical action, so long as the strength is there.

A 25-IN. REFLECTING TELESCOPE for the Harvard Astronomical Observatory is under construction, especially designed for use in stellar photography, and will be ready for use next fall.

LETTERS TO THE EDITOR.

Definitions of "Civil Engineering" and "Mechanical Engineering"

Sir: Now that you have on page 524 of your issue of June 11 taken up the definition of civil engineering, I want to "butt in" too. If you will accept my memory for the definition once given me at college many years ago, the entire field of engineering is divided into two primary divisions, "civil" and "mechanical," according to whether it deals with "statics" or "dynamics." Thus roads, bridges, railroads, canals, dams, harbors, drainage-works, etc., are all branches of civil engineering, for these works are stationary and seldom require the consideration of any laws of motion even incidentally. Mechanical engineering proper, as well as hydraulic, electrical, and marine engineering, etc., are all branches of mechanical engineering, for the things they deal with are in constant motion and their design, construction, and maintenance require a knowledge of the laws of mechanics or dynamics—viz., motion, energy, power.

Does not this seem to be a logical division and at the same time agree with every day usage? Is it not, then, the mechanical engineer "who directs the sources of natural 'power' to the services of mankind?" Respectfully,

Gilbert S. Walker.

1050 Main St., Wheeling, West Virginia, June 14, 1903.

Researches on the Chemical Characteristics of Siloxicon.

Sir: The descriptions of the new refractory substance, Siloxicon, that have recently appeared in the newspapers have created such a widespread interest, as evidenced by the numerous inquiries received from all parts of the country and all lines of industry, that it is desirable to correct a statement that was contained in these publications.

It was there stated that siloxicon was inoxidizable, but recent investigations have shown that this is not true. When it is heated to, or above, 2,674° F. in an atmosphere containing a large amount of free oxygen decomposition occurs.

Siloxicon, while variable in composition, may be represented by the formula $SiCO$, when heated, as above stated, in presence of free oxygen, decomposition takes place, probably in accordance with the following equation:

$$Si_2C_2O + 7\,O = 2\,SiO_2 + 2\,CO_2.$$

If the siloxicon be in the form of a brick or other molded mass, the reaction occurs on the surface, producing a vitreous glaze, which in most instances is tinged light green from the presence of iron.

In the absence of free oxygen or in a reducing atmosphere no such decomposition occurs, and the temperature may be raised to the point of the formation of carborundum, or approximately 5,000° F., before any change occurs, and then it takes place, it is thought, in accordance with this equation:

$$Si_2C_2O = SiC + Si + CO.$$

solid carborundum remaining, while the vapor of silicon and carbon monoxide are given off.

It is interesting to note that after having discovered this oxidation of siloxicon, tests were made with carborundum and it was found to be affected in a manner exactly similar to siloxicon; this notwithstanding the fact that for more than twelve years it had been generally considered inoxidizable. Edward G. Acheson.

Niagara Falls, N. Y., June 18, 1903.

Another Use for Mr. Carnegie's Offer.

Sir: The offer of Mr. Andrew Carnegie to give a million dollars toward a building for the joint occupancy of the several engineering societies of America, naturally awakens great interest in engineering circles and it is presumed that the last word has not yet been said of it. It is an indication of Mr. Carnegie's desire to render liberal financial aid to the engineering profession; but if the beneficiaries could assist in pointing out an application of the money better calculated to advance the great, cardinal purposes of the engineering profession it may be presumed that it is not yet too late to change the specific purpose of the gift. So far as the American Society of Civil Engineers is concerned, it already has a commodious and elegant house, and its gain by the proposed change would be slight. Neither is the question of quarters of vital importance to any of the other societies. Certainly not enough to warrant the acceptance of gifts. These are not eleemosynary institutions. They do not depend upon gifts, and their organization does not contemplate them. They cannot accept gifts for the fulfilment of their ordinary functions, without a certain loss of manly independence and self-respect; though I am aware that this argument has little force among a body of men thoroughly permeated with the American spirit of "grab."

If Mr. Carnegie should devote a large sum of money to the prosecution of experimental researches in engineering subjects, and should make the American Society his custodian and agent in that work, such a trust might be accepted with propriety, and such a work would no doubt be gladly undertaken. My purpose in this communication

is to point out an object upon which the expenditure of a large sum of money, a million or more, would advance the true purpose of engineering to a much greater extent than the establishment of more luxurious quarters, and I trust that the matter will commend itself to the thoughtful attention of Mr. Carnegie as well as to the several societies.

The subject of the flow of water in conduit pipes and open channels is of interest to all branches of the engineering profession, touching deeply upon municipal service, navigation, water power, mining, irrigation, and other pursuits. The scientific basis of this subject is in a deplorably imperfect state. It is not possible to predict, with the necessary accuracy the velocity or loss of head in a given channel, without finding a similar case in which these facts have been determined by experiment. A comprehensive science or reliable theory of the flow of water is yet to be written.

The experiments necessary for the determination of these questions in a manner suited to the requirements of modern engineering, are beyond the resources of any technical school, any private corporation or any engineering society. The U. S. government does not regard such researches as within the sphere of its functions. Only such munificence as Mr. Carnegie is displaying is adequate to the successful conduct of these experiments. Let Mr. Carnegie be seriously advised, instead of coddling the engineering profession by the gift of more luxurious quarters, to really aid it, in its fundamental, primary and most vitally important aims, by devoting his money under such direction as the societies may appoint, to a scientific and experimental inquiry into the laws of flowing water.

Jos. P. Frizell.

60 Congress St., Boston, Mass., June 15, 1903.

Another Set of Hydraulic Diagrams—Continued.

Sir: An author, while he may deprecate the extravagant praise of a friendly critic or the severity of a hostile one, has no right to complain of the honest opinion, whatever it may be, held or expressed by any one regarding anything he has published, provided his work has been examined with sufficient care to justify the formation of an opinion; but the writer believes that it will generally be conceded that an author may with propriety call attention to misstatements of fact regarding his work in the same public manner in which they are made, and it is for this purpose that I now write to you.

In Engineering News of June 4, you publish a communication under the head of "Another Set of Hydraulic Diagrams," referring to some diagrams presented by the writer to the Engineering Association of the South, with some "comments" on the diagrams. The numbers in the parentheses below correspond to the notation used by your anonymous commentator.

(1) The statement is made that sufficient work is required in the use of Diagram I to make it very laborious. As what is very laborious may justly be called a matter of opinion, I shall let this go as an expression of opinion, with the remark that I believe that many of those who may try the diagram for large channels of small slope will entertain a different opinion from that given.

(2) The calculation of the hydraulic radius in many kinds of channels involves the expenditure of considerable time and labor and Diagram II, was designed to diminish this in the case of trapezoidal sections. Commentator says that the utility of this diagram is very limited. This I regard as a misstatement of fact, unless it be meant that the diagram is limited in the same sense that any diagram is; namely, that it only applies to cases for which it was designed. Diagram II, applies to a trapezoidal section with any depth of water, with any bottom width from zero (triangular sections) to 35 times the depth of water, and with any side-slopes from zero horizontal to one vertical (rectangular sections) to side slopes of three horizontal to one vertical. For bottom widths greater than 35 times the depth, the hydraulic radius may be taken equal to the depth without great error.

(3) Under this head there is another statement that is untrue. It is that Diagram III. gives only the factor V. It not only gives V, but it also gives the discharge in gallons per 24 hours or cubic feet per second for circular conduits running full, for all values of from .010 to .020 and for all diameters from 4 ins. to 9 ft. for velocities up to 8 ft. per sec., and for larger diameters to 18 ft. with a smaller range of velocities.

(4) I contend that the statement that Diagram IV. is very incomplete in the data it affords is also untrue. Diagram IV. is intended to facilitate the calculation of velocity and quantity of flow in circular, and the most generally used form of egg-shaped conduits, when flowing partly full. It gives a ratio by which a given quantity must be multiplied in order to then read off the velocity of flow on Diagram III.; and another ratio by which a quantity of flow read off directly on Diagram III. must be multiplied in order to obtain the actual discharge of the partially filled conduit.

(5) The statement that there are really nine diagrams is also untrue. To make out the nine requires the counting of four figures in the text of the article which are inserted merely for the purpose of explaining the construction of the diagrams, and which cannot be used in any hydraulic calculations.

In conclusion, I would state that I consider that in this matter Engineering News has departed from its professed endeavor to be fair in communications published under the head of "Letters to the Editor."

First: In suppressing the name of the commentator. Possibly if his name were known, the reason for the animus with which the comments were made might be apparent. My own inference is that the commentator did not examine the article or the diagrams with sufficient care to justify the expression of any opinion, favorable or otherwise.

Second. In publishing such derogatory comments on the diagrams without giving me the opportunity of replying thereto in the same issue in which they were made.

Yours truly, W. H. Schuerman.

Vanderbilt University, Nashville, Tenn., June 9, 1903.

(There was certainly no intention of unfairness on our part. When our attention was called to the diagrams by a third party we attempted to obtain for our readers a fair estimate of their worth. We suggest, as we did in our issue of June 4, that those having further interest in the subject secure a copy of the diagrams and form their own opinion of them. Following this note will be found another letter on the same subject, from Mr. Robert L. Lund, Secretary of the Engineering Association of the South, who called our attention to the diagrams by the letter published in our issue of June 4.—Ed.)

Sir: I beg to take advantage of my first opportunity after an absence from the city to refer briefly to the comments of your reviewer, printed in connection with my letter in your issue of June 4, regarding Prof. Schuerman's hydraulic diagrams.

Considering in order the comments made, it is first stated:

> Diagram I. is a modification of the Kutter Diagram . . . and though it involves less work in the determination of V, it still requires sufficient work to be very laborious.

The diagram, however, is not a modification of the Kutter diagram, and the "laborious work" of finding V is as follows: Stretch a thread for one intersection, from which follow a straight line to another intersection, at this point read V. This operation finds V for any section, slope, or coefficient of roughness.

The diagram differs from that of Kutter in two material respects: (1) It employs entirely different roughness and slope curves such that $C\sqrt{S}$, in the equation, $V = C\sqrt{RS}$, is determined, instead of C only as with the Kutter diagram. (2) It has an added set of lines, all straight, by means of which $C\sqrt{S}$ is multiplied by $\sqrt{R}$. In other words, the Kutter diagram determines C, which must then be multiplied by $\sqrt{RS}$; the Schuerman diagram determines directly $C\sqrt{RS}$, all multiplication and extraction of roots being avoided.

Regarding Diagram II. the reviewer states:

> Diagram II. gives hydraulic radii of trapezoidal canals. This is only one factor out of many in the solution of canal hydraulics, and is only the first step in obtaining discharge data. The utility of the diagram is very limited.

We must grant Professor Schuerman indulgence for having attempted the solution of but one factor of hydraulic problems in a diagram that consists of but two sets of straight lines at right angles to each other, covering about five square inches of diagram. However from this diagram may be read the hydraulic radius of any trapezoidal section flowing to a depth of from 0 to 500 of any unit, with a bottom width of from 0 to 35 times the depth, and with slopes from vertical to 3:1; including the triangle and rectangle as special cases of the trapezoid. For the purpose it is intended to serve its range seems to be quite unlimited.

Diagrams I. and II. are intended for use together in the solution of problems relating to trapezoidal sections. The saving effected by their use is indicated by the following statements of solution of problem, given slope, dimensions of section, depth of flow, and coefficient of roughness, to find velocity of flow:

Using Kutter's diagram the process would be as follows: (1) Figure area of section. (2) Figure wetted perimeter. (3) Figure hydraulic radius. (4) Determine square root of hydraulic radius. (5) Determine square root of slope. (6) Read C from diagram. (7) Figure velocity, the product of C by $\sqrt{R}$ by $\sqrt{S}$. Using Schuerman's diagrams the process would be: 1. From Diagram II. read hydraulic radius. 2. From Diagram I. read desired velocity.

No further proof of the utility of these diagrams should be necessary.

The third statement of the reviewer is:

> Diagrams III.-A, III.-B, and III.-C. give only the factor V, and in order to obtain the discharge it will be necessary to compute, in every case, the area and (of?) the cross-section, and then compute the discharge from the equation Q = AV.

It is difficult to understand how the reviewer failed to see the graduations across the top of this diagram, boldly lettered "Discharge in Cubic Feet per Second," and "Discharge in Million Gallons per 24 Hours," from which these quantities may be read with all necessary accuracy and without any computation whatever.

This diagram solves all problems relating to circular conduits running full, and together with Diagram 7[illegible] as will be explained below, all problems relating to circular conduits running partly full, and to egg-shaped conduits running full or partly full, and is probably the most useful hydraulic diagram ever constructed. It shows all commercial diameters of manufactured pipes from 4 ins. up, and each even foot diameter above 6 ft. up to 18 ft. In all problems any value of n may be employed, enabling the determination of the difference in discharge, loss of head, etc., for varying conditions of interior surface of conduit, important information not easily obtained by any other means. It is interesting to note that there is but one set of curved lines on this diagram, those for n, and that their curvature is slight.

Of the five factors involved in problems solved by Diagram III., viz., Roughness, Diameter of Conduit, Slope, Velocity, and Discharge, any combination sufficient to determine may be assumed and the others read off from the diagram by inspection. An interesting application of this feature of the diagram is in the examination of Weston's valuable "Tables of Loss of Head," etc., in new cast iron pipes. The values given in these tables are shown by the diagram to correspond to varying, instead of constant, values of n, the variation being from 0.0090 for 4-in. pipe, to 0.0140 for 60-in. pipe. A line corresponding to these varying values of n may be drawn on the diagram, and by its use the values given in Weston's "Tables" may be read from the diagram.

Regarding Diagram IV. is stated:

> Diagram IV. is a combination of three ratio diagrams, one for circular and two for egg-shaped sections. It is very incomplete in the data which it affords.

The data which the diagram afforded the reviewer is remarkably incomplete. From his comment it seems probable that he failed to perceive its purpose. As indicated above, the diagram is designed for use in connection with Diagram III. The method is as follows, having given, for example, a circular conduit flowing partly full. Diagram IV. shows: (1) The diamater of pipe which, flowing full, has the same hydraulic radius. (2) The diameter of pipe which, flowing full, has the same area of flow. With this data Diagram III. solves by inspection all other factors of the problem, for any value of n. For egg-shaped conduits, flow.n_0 full or partly full, the process is the same. The egg-shaped section used in the diagram is of the proportions ordinarily employed, viz.: Radius for large end twice, and for sides six times, that of small end; however, lines for any other section could readily be drawn.

The final comment of the reviewer is: "Instead of four diagrams there are really nine." As constructed, Diagrams I. and II. are combined for convenience and printed on one page. Diagram III. is printed, also for convenience, in three parts, each occupying one page; thus making with Diagrams IV., five pages, though Professor Schuerman considers that there are but four diagrams, and it would seem properly so. There are in addition four figures in the text explaining the construction of these diagrams, as well as of others which would serve the same purpose; these make out the nine diagrams discovered by the reviewer.

The method of using the diagrams is easily learned, a full set of examples given with them explaining all cases that may arise. Their arrangement is so simple, however, that one accustomed to hydraulic computation can understand their use even without reading the explanations. They practically eliminate arithmetical computation in the solution of problems relating to the flow of water, the only figuring required being:

(1) In Diagram I., to compute for trapezoidal conduits the area of flow, and to multiply same by the velocity.

(2) In Diagram II., to divide width of bottom by depth of flow.

(3 In Diagram IV., to multiply given diameters by ratios read off.

Ordinarily most of these can be performed mentally. Concluding, permit me to express a natural surprise that the News has not secured a more trustworthy review of a simple set of hydraulic diagrams.

Respectfully, Robt. L. Lund.

Nashville, Tenn., June 16, 1903.

Diagram for Concrete-Steel Beams.

Sir: I should be much obliged if either you or Mr. Schaub would kindly solve the following difficulty a young student experiences in reading the letter on the above subject in your issue of April 16, 1903.

(1) Am I to understand that the moment of resistance is destroyed below the neutral axis after the cracks have appeared?

(2) Hence are the stresses below the neutral axis purely shearing?

(3) How can a "stress in a horizontal plane" have "a vertical component?"

(4) What is meant by "metal in the horizontal plane?" Why is not y_1 the shearing area required and not $(y_2 - y_1)$?

I hope that I am not especially dense in this matter,

but it is so rarely that engineers in this "worn out" old country are called upon to use the lines of internal stress that I venture to ask your help.

I find your paper an immense help to me in my work as a civil engineer. Here all our best representative papers are given over to battleships and machine tools and are practically useless to such as myself.

"Student."

33 Bamford Road, Didsbury, England, May 10, 1903.

(We submitted the above letter to the author of the article referred to, and print his reply below.—Ed.)

Sir: Replying to the questions of "Student," I would answer as follows:

(1) Yes, as far as the concrete in tension is concerned.

(2) Yes, as far as the concrete is concerned.

(3) The stress in the horizontal plane is induced by internal stresses which act at 45° and which have horizontal and vertical components.

(4) The metal in the horizontal plane is the metal which is straight, from end to end, in the tension flange, and which therefore can resist horizontal stresses only. The expression $(y_2 - y_1)$ represents the increment at any point received by the metal in a horizontal plane; hence, y_1 alone would represent the sectional area of metal required at any point in the tension flange. For example, if $x_1 = 0$, then $y_1 = 0$; and if $x_1 = \frac{1}{2}$, then $y_1 = A$. It follows that $(y_1 - y_1)$ equals the sectional area required in the stirrups at any point, inasmuch as it has been shown that the stirrups must carry the vertical components of the stresses which produce the tension on the metal in a horizontal plane

It should be explained that the use of stirrups is necessary only for short and deep beams, and even then it is a question, in the light of some recent experiments made by the writer, if the desired result cannot be obtained in a much simpler way. This question, and the entire question of concrete and concrete-steel, should be taken up by a committee to be appointed by the American Society of Civil Engineers. This was the sense of the Annual Convention recently held at Asheville, and which will be acted upon at the next business meeting of the society.

Yours truly, J. W. Schaub.

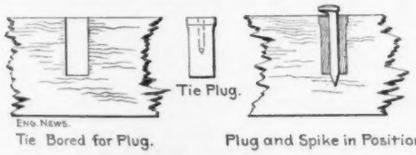
1650 Monadnock Block, Chicago, Ill., June 15, 1903.

Notes and Queries.

In the article on the Spier Falls dam, appearing in our last issue, we omitted to state that E. H. Gay & Co., of Boston, Mass., financed this undertaking.

A correspondent states that he finds engineers differ widely as to the cubic contents of cement barrels, and asks for authoritative references. In our issue of Oct. 4, 1900, will be found data as to domestic and foreign Portland cement barrel contents, which are reprinted on p. 423 of our issue of Dec. 5, 1901.

In the letter on "Hardwood Plugs to Hold Spikes in Soft-Wood Ties," by the Director of the Danish State Railway, printed on p. 548, of our last issue, a cut illustrating the proposed plug was accidently omitted. We therefore print it herewith, as it makes the construction proposed by the Director plain at a glance.



Tie Bored for Plug. Plug and Spike in Position.

Details of Hardwood Plug for Holding Spikes in Soft Wood Ties.

THE STEAM TURBINE FROM AN OPERATING STANDPOINT.*

By Fredk. A. Waldron,† M. Am. Soc. M. E.

The steam turbine which this paper will describe is installed at the works of the Yale & Towne Manufacturing Co., Stamford, Conn., and is the first one of its size (outside of those operated by the builders) to be put into practical operation in this country. After a thorough investigation by the writer, in the early part of 1901, it was decided to install a Westinghouse-Parsons steam turbine for the following reasons: (1) Floor space. (2) Economy. (3) Continuous operation of existing plant during installation of the new.

The generating outfit consists of a two-phase, 240-volt alternator, of 400 kilowatts capacity (when the turbine was running condensing, and the power factor of the alternator was from 90 to 100%), 7,200 alternations, running at 3,600 r. p. m., with a separate, direct-connected exciter set. The alternator is of the revolving field type, and the surface speed of the field is 22,137 ft. per minute. The weight of the outfit is 33,200 lbs., and occupies a floor space 19 ft. by 4½ ft. The guaranteed economy was 16½ lbs. of water per E. HP. at the switchboard, with 28 ins. of vacuum, 40° F. superheat, and 155 lbs. gage pressure. Tests for economy, under slightly different conditions, reported later in this paper, will show how nearly the guarantee was reached. This opens the question of what is the average ratio between an indicated horse-power at the engine and an electrical horse-power at the switchboard.

The electrical end of the machine is not compounded, and the variation in voltage depends entirely, within certain limits, upon the load and position of rheostats. Speed regulation is very close and perfectly satisfactory. A true kilowatt overload of 33⅓% has been carried for five consecutive hours, without apparent injury to the machine. Owing to the low power factor, however, the heat developed in the field and terminals was much higher than is allowable in good practice. When thus overloaded, the volt-meter had to be closely watched, in order to care for any suddenly applied load with the rheostat.

At present, the condenser plant consists of a surface condenser, containing 1,100 sq. ft. of cooling surface, with independent air and circulating pumps. The air-pump is of the simplex, twin beam, vertical type, making about 90 single strokes per minute. The average vacuum obtained with this outfit, with plenty of circulating water, is about 27.4 ins. This outfit is to be replaced by one of more recent design, and operated on the "Dry System" and with a two-stage vacuum pump. Steam is furnished by eight Manning boilers.

MOTORS.—Sixty-four (64) induction motors (with varying loads), ranging from ⅛ to 40 HP., are distributed throughout the works. With the exception of the elevator motors, the entire plant is arranged on the group system. Wherever one or more machines are to be driven, belting or gearing is used, and, if room will permit, belting is given the preference, for the following reasons: (a) Flexibility. (b) Less wear and tear on the motors. (c) Absolute independence of speed of line shafts. (d) Convenience in case of repairs. (e) The advantage of changing, in event of increase or decrease of power requirements. (f) Equal, if not higher, efficiency under continuous working conditions.

With this arrangement, the power factor will range from 82 to 86%, depending on the motor loads. The only precaution to take, in order to prevent frequent shut-downs, with the induction motor, is to have the main circuits fused heavy enough to withstand the influx of current to the line, due to starting.

Owing to manufacturing requirements, it is found necessary to run the shafting both lengthwise and crosswise with the building. The electric system of transmission lends itself admirably to this condition. Had this factory been one continuous building of from two to four stories high, with the power house centrally located, shafting running in one direction, and light machinery installed along its line continuously, the question of the economy of electric transmission would have been doubtful.

THE TURBINE AND ITS GENERATOR.—The turbine end of this machine has received very little attention in the past year, and has required no renewals or repairs to any of its parts; in fact, from an operating standpoint, it is almost fool-proof. It was found necessary, when assembling the machine, over a year ago, to remove from the bearings, with a fine oil-stone, some burrs which had been thrown up in handling, and also a little rust which had accumulated; upon examination of the same, one year later, these marks had not been worn out, and there was absolutely no difference in the recorded diameters of the bearings, covering a period of one year's wear.

Occasional longitudinal adjustment, to check the clearance between the blades in the case and the revolving element, is necessary. The wear and tear on other parts of the machine have been practically nil, and if the oil is kept in constant circulation and properly cooled, there is no need of a "hot box," and the amount of oil used is extremely small; the consumption of this particular machine being ½ gallon of cylinder oil per week, and from 3 to 5% of the lubricating oil on the bearings may be said to be wasted. The quality of the oil used should be perfectly free from acids which would, in any way, tend to injure the bearings. Considerable apprehension has been felt by a great many who have not come in actual contact with the turbine that the blades in the revolving element would be a source of trouble. If the machine is properly set and adjusted, with a chance for expansion between the machine and its condenser, there is (outside of defective material) absolutely no danger from these blades. It is necessary to remove the top of the case of the turbine once in three months (especially when the plant is first started), as red lead or other foreign substances in the pipes are liable to clog the smaller blades, although a steam strainer is provided, which cares for any foreign substances which may in any way injure them.

The principal trouble with the steam end is its liability to shut down, when running from ¾ to full load, because the vacuum is destroyed. This can be prevented, if the engineer is on hand, but sometimes he isn't there, and we have had one or two shut-downs, in the last year, from this cause. I am informed, however, that a device for automatically preventing this is being designed by the makers, and we expect to have it on our second machine.

It is desirable to place in the pipe for cooling water for the oil well an eel-trap with a by-pass, and, what is still better, if convenient, to have two sources of water supply. An open drip should also be provided, which can be frequently tried by the engineer, to insure proper circulation of cooling water. The electrical end of the machine has given us all the trouble—not from the result of electrical design and defect, but from mechanical defects, pure and simple.

The field or revolving element is made of four cylindrical forgings, 23⅝ ins. in diameter, aggregating in length about 28 ins. These sections are forced onto a shaft, with about 150 tons pressure. Owing to centrifugal force and the heat developed in the field, one of these sections crept on the shaft about ¾-in., the result being that, on Aug. 21, 1902, one of the field wires was pulled apart. Repairs were quickly made and the makers agreed to furnish us a new field, which was placed in position the latter part of December; when, upon starting the machine for the purpose of testing, it immediately (upon attaining full speed, and without any load upon it) flew into a large number of pieces, entirely demolishing the electrical end, and badly damaging the steam end. Investigation showed that invisible flaws in the forging were the cause of this accident. No damage was done to the building, outside of the breaking of a few panes of glass, neither were any of the occupants injured, although there were eight men in the room at the time.

From the various accounts of fly-wheel accidents, I think that the majority of the members, after observing the photographs which the writer will exhibit to those who desire to look at them, will admit that, in spite of its high speed, the field of devastation is not so great in the case of the turbine as the reciprocating engine.

A memorandum has been kept by the author of all of the questions which have been asked him in regard to this installation, and, as a matter of record, he would like to place the more important ones before the Society, in the order of their importance:

(1) Does it fulfill the guaranteed economy?

In answer to this see Table No. 1.

(2) Is the windage excessive?

It certainly is more than from a slow speed generator, yet, as a whole, is not disagreeable, as noise in the engine room is a comparative quantity.

(3) Are you satisfied with the continuity of operation?

Outside of the breakdown (which was due to defective material, or to causes entirely foreign to the machine), it is entirely satisfactory.

(4) What condensing outfit is necessary?

This is a question which each purchaser can best decide for himself. The writer's experience, however, is that the best is none too good, and that for continuous running and high vacuums, the dry system, with a two-stage air-pump, will probably maintain higher average vacuums than any other system.

(5) Can exhaust steam be used for heating?

This turbine has supplied 25,000 sq. ft. of direct radiating surface and 7,500 sq. ft. of blower-stack surface, and maintained a temperature of from 60° to 70° F. in all buildings, when generating 320 KW., and with a temperature of 220° F. in the exhaust chamber of the turbine. The differential in pressure was produced by 10 ins. of vacuum on the power house end of the drips for the heating system. The writer has also found that the temperature in the exhaust chamber of the turbine varies with the different loads, and at full load and overload, there is more or less superheat, whether running condensing or non-condensing.

(6) What overload will it stand?

A 50% overload has been maintained at full speed, for five hours, without apparent injury to the machine.

(7) Can it be changed from condensing to non-condensing, and vice versa, when running?

This we have done daily, during the heating period, and without difficulty or shut-down, according to the following schedule:

Non-condensing, 7 a. m. to 10 a. m.; 1 p. m. to 3 p. m.

Condensing, 10 a. m. to 12 m.; 3 p. m. to 6 p. m.

(8) Type of exciter?

The exciter should be driven by an independent engine.

(9) Is your confidence in the machine shaken, after the trouble you have had with it?

The best reply to this is that a second outfit has been ordered.

(10) Cost?

Upon the basis of strictly competitive prices, the turbine, ready to run, costs from 10 to 15% less than the same sized reciprocating engine outfit.

The cost of the power house, per square foot, per kilowatt, would be about 65% less for a turbo-generator outfit than for a reciprocating engine of the same power and economy. The cost of foundations is taken into account

*From a paper presented at the Saratoga meeting of the American Society of Mechanical Engineers.

†Supt. Power Plant, Yale & Towne Mfg. Co., Stamford, Conn.

in the cost of the engine and turbine. The cost of piping is not included in either case, excepting the piping between the throttle and the condenser.

(11) Is the vibration excessive?

The author considers that, unless it is possible to balance a lead pencil on the outboard bearing and allow it to remain there for a minute, the machine is vibrating more than it should; and while there are no foundation bolts to hold the machine down, there has been no tendency for it to creep on its foundations.

It may be interesting to know that the foundation of Turbine No. 1 cost $188.60, at the current prices of cement, sand and broken stone, in 1901-2. It is advisable to leave the foundations with a tunnel through the center, transversely, as there are many ways in which these tunnels can be utilized, either for piping or ducts for electrical wiring.

In the tests of the turbine, no special attempt was made to obtain an unusual vacuum. The condenser was tested for leakage, and all water was measured from the air-pump discharge. The power for the exciter (10.8 kilowatts) was determined in a separate test. The exhaust from the exciter engine is used for heating purposes. Shop tests on the turbine made 18 months before the test of this paper, showed an economy of 14.47 lbs. of water per brake HP. with a load of 607 brake HP. and 16.43 lbs. of water per brake HP., with a load of 263 brake HP. (200 KW.) These tests were under approximately the same conditions as to pressure, vacuum and superheat as those in this paper.

The tests on motors are intended to present detailed losses of power transmission, as applied to the group system, with different arrangements of line shafting and belting, as well as different applications of the electric motor to factory work.

The principal points brought out by the tests are:

(a) Difference in frictional losses, depending on speed and arrangements of shafting in the different rooms.

TABLE II.—Results of Tests of Electric Induction Motors Driving Machinery in the Works of the Yale & Town Co.

DATA.	Test No.	Building	Location: Room.	Location: Kind of work.	Connection: Size B & S gauge	Connection: Length of line per Phase in Feet	Energy at switchboard A: K W	Energy at switchboard A: H P	Average Motor Load. Input B.: K W	Average Motor Load. Input B.: H P.	Average Motor Load. Output C.: K W	Average Motor Load. Output C.: H P	Nominal Rating of Motor in H P	Transmission Losses. Electrical. Line loss D=A−B: K W.	Transmission Losses. Electrical. Line loss D=A−B: H P.	Transmission Losses. Electrical. Motor loss E=B−C: K W.	Transmission Losses. Electrical. Motor loss E=B−C: H P.	Transmission Losses. Mechanical. Shafting F: K W.	Transmission Losses. Mechanical. Shafting F: H P.	Transmission Losses. Mechanical. Shafting and Machines Idle, G.: K W.	Transmission Losses. Mechanical. Shafting and Machines Idle, G.: H P.	Efficiencies. Line (C÷A): %	Efficiencies. Motor (Commercial) (C÷B): %	Efficiencies. Electrical* (C÷D): %	Water rate per hour at Motor Pulley: Per H P.	Water rate per hour at Motor Pulley: Per K W.	Coal rate per hour at Motor Pulley: Per H P.	Coal rate per hour at Motor Pulley: Per K W.
NUMBER OF TEST.	7	17	Rod shop	Automatic screw machinery	No. 00	250	34.6	46.1	33.2	44.5	26.66	36.	37.5	1.2	1.6	6.36	8.5	14.9	17.3	21.6	29.	96.3	81.	78.				
	8	10	105	Gen'l machining	" 4	300																						
	9	19	Cabinet lock shop	Gen'l machining; pulley & buff'g	" 0000	350	13.35	17.9	13.	17.43	11.05	14.8	15.	.35	.47	1.95	2.6	5.6	7.5	10.4	22.	97.5	85.	82.8	27	30.2	3.09	2.1
	10	34	Iron Foundry	Cupola blower & heating system	" 00	1,000	31.2	41.8	30.	40.2	24.66	33.2	35.	.6	1.67	5.15	6.9			2.4	3.22	96.2	82.	80.	27.9	30.6	3.2	2.9
	11	2	25	Plating dynamos and exciter	" 00	300	5.14	6.89	5.	6.7	4.05	5.43	10.	.14	.19	.95	1.27			.93	1.25	97.3	81.	79.	28.2	31.1	3.3	3.0
	12	4	41	Polishing and buffing	" 0000	500	33.1	44.4	32.5	43.6	28.2	37.8	40.	.6	.8	4.3	5.8	21.1	28.3	32.7	30.5	98.2	87.	85.2	25.2	29.5	3.0	2.8
	13	2	24	Polishing and buffing	" 00	150	37.9	50.4	36.5	48.5	32.35	30.2	30.	.7	.94	3.95	5.3	12.5	16.5	17.9	24.	97.6	85.	83.	26.8	29.	3.06	2.8
	14	4	44	Ventilating system	" 0000	400	26.42	35.4	25.7	34.4	20.7	27.7	30.	.72	.96	5.	6.7					97.5	80.5	78.4	28.5	35.3	3.7	3.4
	15	2	24	Ventilating system	" 2	200																						
	16	10	101	Heating system	" 4	350	47.2	63.26	46.56	35.7	31.36	38.7	30.	.64	.86	5.2	7.					97.7	80.5	79.7	28.4	31.2	3.3	3.0
					" 0000	500																						
	17	18	Smith shop	Drop forging	" 4	60	25.8	34.7	24.4	32.8	19.9	26.75	30.	1.4	1.9	4.5	6.05					94.8	81.5	77.2	28.9	31.6	3.2	2.9
					" 8	240																						
	18	4	47	Plating dynamos	" 00	250	18.47	24.8	18.1	24.3	15.65	21.	30.	.37	.5	2.45	3.3			15.	20.1	97.8	86.5	84.5	26.4	29.7	3.05	2.8
					" 2	300																						
	19	47	Tool, mach. & press shop	Tool making and press work	" 0000	500	62.3	83.9	61.	82.3	49.	66.	60.	.8	1.1	5.3	7.1			5.6	7.5	89.6	86.5	85.2	26.2	29.5	3.01	2.8
					" 00	350	35.	48.25	33.6	47.7	28.8	38.6	30.	.4	.55	6.8	9.1	14.9	20.	33.5	45.	98.5	81.	80.	27.9	30.8	3.2	2.9

* Ratio of energy delivered at motor pulley to energy at switchboard

(b) The power utilized by the machinery, when running idle.

(c) The total power used by the shafting, machinery and useful work.

(d) Efficiency of electric transmission.

The tests were made under actual running conditions; the test for each room being continued for one half day, with regular working load, and readings of the watt meter were taken every two minutes. The mean vibration of the pointer was taken as the true reading. The efficiency of the motors (under their different loads) was taken from the curves furnished by the builders.

The analysis of these tests would indicate that, with the turbo-generator driving induction motors, and with an evaporation of 8.707 lbs. of water, per lb. of coal, a brake HP. can be delivered from the pulley of the motor for about 2½ lbs. of coal (see table of tabulation of motor tests 7 to 19 inclusive), with a turbine of this size running under average economy. (This allows 5% for banking.)

Under the same evaporative conditions, the average non-condensing engines, distributed through the different rooms in the plant, would require 7.5 lbs. of coal per brake HP. at the flywheel, or three times the quantity required for the electrical drive.

As to what would be the actual saving under the existing conditions at this factory, over belt transmission, it would be impossible to calculate, as the conditions which exist at the present are so entirely different from former conditions, owing to the rapid growth of the plant.

What the loss might have been between the engine and pulleys which deliver power to the different rooms, is an unknown quantity. Further, under the conditions which existed at that time, and do exist now, about one-half our steam is utilized for manufacturing purposes and for heating. The question, therefore, of the comparative total cost of power, is a matter which must be arbitrarily determined, depending on the ratio of the power house charges for power and manufacturing steam. As this is entirely arbitrary, it is not permissible to quote any figures as to the relative costs of power, under the two conditions, as they would be inaccurate and misleading to others.

One of the interesting questions answered by these tests is the small amount of power actually used in removing stock, in light manufacturing work.

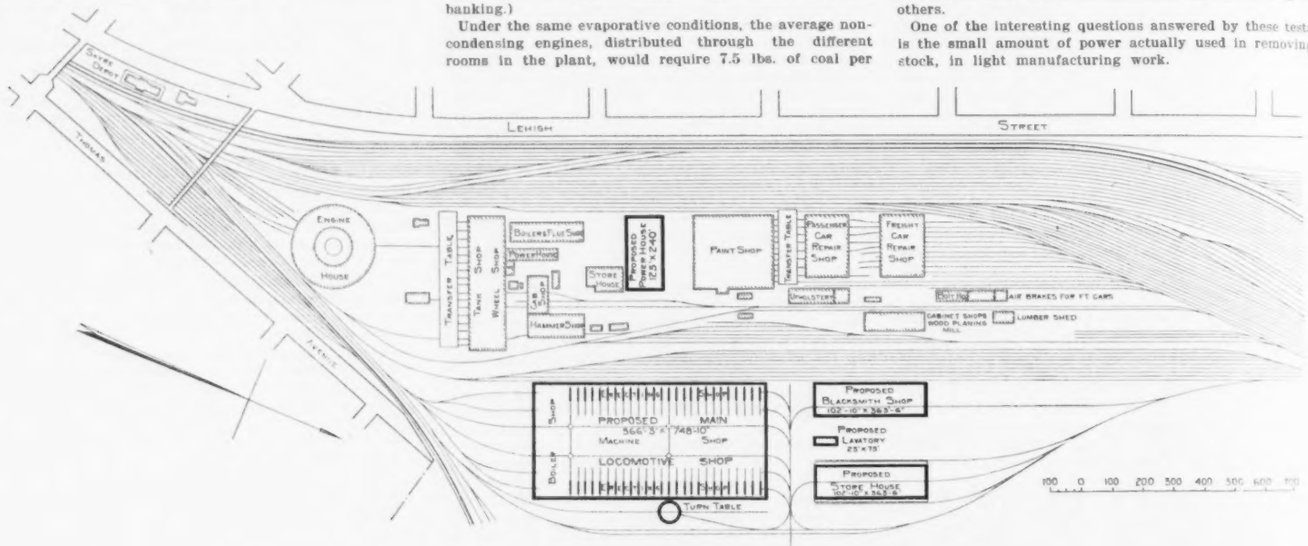


FIG. 1. GROUND PLAN OF LOCOMOTIVE SHOP EXTENSION AT SAYRE, PA., LEHIGH VALLEY R. R.

TABLE I.—Results of Economy Tests of a 400-KW. Westinghouse-Parsons Steam Turbine Generator at Various Loads.

Test No.	2.	3.	4.	5.	6.
Voltage	227.5	227.5	227.5	227.5	238.7
Average revs. per min.	3,600	3,600	3,600	3,600	3,500
Maximum speed variation, as pr tachometer	0.5%	0.5%	0.5%	0.5%	0.5%
Average load	152 KW.	323 KW.	375 KW.	397.11 KW.	490 KW.
Average water per hour	4,263.3 lbs.	7,217.3 lbs.	8,358.5 lbs.	8,798.60 lbs.	10,625.8 lbs.
Duration of test	3 hrs.	3 hrs.	4 hrs.	3 hrs.	5 hrs.
Steam pressure (per gage)	144.85 lbs.	153.3 lbs.	152 lbs.	150.92 lbs.	152.7 lbs.
Superheat at throttle	.....	3.44° F.	6.46° F.	19.66° F.	18.2° F.
Average vacuum	27.34 ins.	27.64 ins.	27.43 ins.	26.95 ins.	27.55 ins.
Water per KW., per hour	28.05 lbs.	22.34 lbs.	22.29 lbs.	22.156 lbs.	21.7 lbs.
" " E.HP. = Water pr KW.-hr. × 746 / 1,000	20.92 "	16.67 "	16.63 "	16.53 "	16.18 "
" " B.HP. = general efficiency (0.91) × water pr E. HP., pr hr	19.03 "	15.17 "	15.13 "	15.04 "	14.72 "
" " I. HP. = water per E. HP. per hr. × 0.85	17.78 "	14.17 "	14.13 "	14.05 "	13.75 "
Maximum average load for 1 hr.	152 KW.	323 KW.	383 KW.	398.26 KW.	525 KW.
Minimum average load for 1 hr.	152 "	323 KW.	367 KW.	394.92 KW.	432 KW.
Maximum superheat	.....	9.97° F.	18.27° F.	24.27° F.	26.6° F.
Maximum water rate per KW.-hr.	28.27 lbs.	22.70 lbs.	23.11 lbs.	22.45 lbs.	22.33 lbs.
Minimum water rate per KW.-hr.	27.91 "	22.03 "	21.46 "	22.18 "	21.22 "
Maximum vacuum	27.42 ins.	27.71 ins.	27.84 ins.	27.85 ins.	27.65 ins.

Note.—Test No. 2 was made after working hours, with the boiler running very light, which accounts for the low pressure and lack of superheat.

In conclusion, the results obtained from this outfit may not be any higher than many obtained by direct connected sets of the same size, running under maximum economical conditions. Assuming, however, that they are the same, the advantages of initial investment, constant economy and the possible extension of the plant with the turbo-generator outfit, are of sufficient importance to warrant the installation.

The strongest appeal, however, that the turbo-generator makes to the business man or the engineer is its inherent commercial efficiency. By this, I mean that its efficiency is unchanged, week in and week out; year in and year out. Leaky pistons or valves, lack of alinement of slides and bearings, keying up, and, above all, lubrication, all of which exist in the reciprocating engine, are eliminated in the turbine.

PROPOSED NEW SHOPS FOR THE LEHIGH VALLEY R. R., AT SAYRE, PA.

In our issue of May 28 we gave a brief note of the extension of the railway repair shops at Sayre, Pa., which is planned by the Lehigh Valley R. R. Through the courtesy of Mr. Walter G. Berg, M. Am. Soc. C. E., Chief Engineer of the company, we are now able to show general plans of the work and give some additional information in regard to it.

The ground plan, Fig. 1, is a map of the existing shops and track facilities at Sayre, on which the

new buildings are drawn in with heavy lines. The principal one of the new buildings is an immense structure which is to be a combined machine shop, erecting shop, and boiler shop. Two smaller buildings, each of which, however, is of quite respectable size, are a blacksmith shop and a storehouse. The fourth building is a central power house which will generate and supply power for the entire plant, which it is proposed to operate by electric motors throughout.

The storehouse and the blacksmith shop, cross-sections of which are given in Figs. 2 and 3, show nothing unusual in their arrangement. The large main locomotive shop, however, is arranged on a novel plan. Machine and erecting shops are combined in one building, one end of which is utilized as boiler shop. The (two) erecting shops themselves are of the transverse arrangement, and all shifting from track to track is done by enormous overhead traveling cranes instead of by turntables or transverse carriages. The transverse arrangement of erecting shop represents most recent

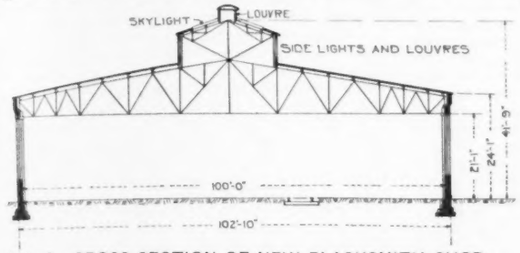


FIG. 2. CROSS-SECTION OF NEW BLACKSMITH SHOP.

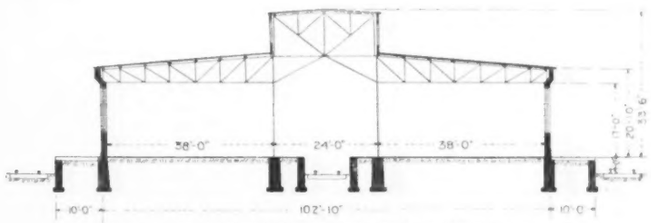


FIG. 3. CROSS-SECTION OF NEW STOREHOUSE.

practice, the new shops of the Philadelphia & Reading Ry., at Reading, Pa., of the Lake Shore & Michigan Southern Ry., at Collinwood, O., and of the Pittsburg & Lake Erie Ry., at McKees Rocks, Pa., being of the same type. A similar system has been in use at the Baldwin Locomotive Works, and at the Brooks Locomotive Works for about ten years, and the same system has been recently installed at the Richmond Locomotive Works and the Paterson Works. A modification of this system is in use by the Pennsylvania R. R. in the old machine shops at Altoona, Pa., where a heavy overhead traversing crane has been introduced in place of a transfer table.

The combined shop building, a cross-section of which is shown in Fig. 4, is described by Mr. Berg as follows:

The main locomotive shop will have an erecting shop with 48 erecting pits, divided into an east and a west section, each section being 60 × 627 ft. Between the two sections will be the machine shop, 156 × 627 ft. At one end of the building will be the boiler shop, 121 × 366 ft. The machine shop will be divided into two bays, each 60 ft. wide, and a central bay 36 ft. wide. The central bay will have a gallery over it for the heating apparatus, toilets, lavatories, lockers, etc. The space under the gallery will be utilized for small machinery, benchwork, link and motion work, toolroom, etc. Between each erecting shop and the machine shop there is a 42 ft. space, 627 ft. long, called a covered yard. This space is to be used as an overflow storage ground for both the erecting and machine departments, making a conveniently located space inside the building in place of an open yard outside the building for storage of dismantled parts and miscellaneous materials. In this space will be located the storage pits, lye vats, tire shrinking platforms, etc. This plan gives the result that all locomotive repair work, with exception of blacksmith and forge work, will be conducted in one large building with overhead cranes serving all important points.

All the traveling cranes in the building (their number and capacity are shown in the section, Fig. 4), extend into the boiler shop. As will be seen the erecting shop on either side has two cranes superposed, the upper one being of 120 tons capacity.

The general equipment of the buildings is sketched in the following statement:

The buildings will generally have concrete foundations, brick walls, steel frame and roof trusses, covered with slag roofing laid on concrete—steel roof construction. The floors will be, generally, wood on concrete beds. In the higher grade buildings the top floor will be maple, in other buildings yellow pine. The blacksmith shop and part of the boiler shop will have a cinder floor. Side windows will have plain glass and in the main locomotive shop factory-ribbed glass. Roof lights and monitor lights will be wired glass. The heating of the main shop will be by a hot air blower system, the fans being run by motors and the heater units supplied with exhaust steam from the power plant. All other buildings will be heated by direct steam radiation.

The machines will be driven by electric motors, by a suitable combination of individual and group driving. The lighting will also be electric. The details of power plant and machinery have not yet been determined. All pipes and main wiring will be conducted from the central power plant through an underground tunnel and ducts to the various buildings. Proper provision will be made for water supply, fire service, drainage, sewerage, sanitary arrangements, etc.

The map, Fig. 1, does not show the entire development contemplated at Sayre. The Lehigh Valley R. R. intends to gradually rearrange the existing plant and add new buildings until all the repair work is concentrated at this point. The complete works will comprise three groups of buildings, respectively, for the repair of locomotives, passenger cars and freight cars. The work described above, and to be executed during the next two years, covers only the first group, the locomotive repair shops. The work of preparing the site is now being taken in hand.

THE BURSTING SPEED OF EMERY WHEELS.*

By Charles H. Benjamin,† M. Am. Soc. M. E.

Several years ago the writer was consulted regarding some points of a case in litigation occasioned by the bursting of an emery wheel and the resulting death of a workman. The question to be decided was whether the wheel was unsafe at the speed recommended by the makers, or whether the accident was due to the carelessness of the operator. As it was just then an off year for experiments on fly-wheels there seemed to be no good reason why the same medicine could not be tried on emery wheels. The apparatus already described in former papers read before this Society (Eng. News, Dec. 1, 1898), with some slight alterations, was adapted to the new requirements, and in the spring of 1902, 15 wheels of various makes were tested to destruction.

For the actual details of the work credit is due to Messrs. Chandler and Krueger of the class of 1902, Case School of Applied Science. Most manufacturers of this class of wheels test them for their own information, but the results are not generally given to the public; the writer knows of no published data on this subject. At the Norton Emery Wheel Works, all wheels are tested before leaving the shop at a speed double that allowed in regular service, and occasionally wheels are burst to determine the actual factor of safety. Emery-wheel accidents are not uncommon, but can usually be traced to the carelessness of the operator. One common cause of failure is allowing a small piece of work to slip or roll between the wheel and the rest. The writer was once present at an occasion of this kind, and although he fortunately was not in the plane of rotation, he has never forgotten his sensations.

The wheels selected for the experiments were all of the same size, being 16 ins. in diameter by 1 in. thick, and having a hole 1¼ ins. in diameter. The object of the experiments being to determine the bursting speed of such wheels as are actually on the market, emery wheels were obtained through various outside parties without indicating to the agents or manufacturers the use to be made of them. In this way wheels of six different makes were obtained, the label on each wheel showing usually the maker's name, the grade number or letter, the quality of emery and the speed recommended for use. As shown in the accompanying table of results, the working speed varied in the different wheels from 1,150 to 1,400 revolutions per minute, the average being about 1,200 revolutions per minute. For a diameter of 16 ins. this corresponds to a peripheral velocity of about 5,000 ft. per minute. The table also shows that the fineness of the emery varied from 10 to 60, the average being about 30.

Table Showing Results of Tests of Bursting Speed of Emery Wheels.

			Speeds					
			Working		Bursting			
No. of test.	Grade mark.	No. of emery.	Revs. per min.	Feet per min.	Revs. per min.	Feet per min.	Speed ratio.	Factor of safety.
1.	4.5	20	1,200	5,030	3,100	13,000	2.58	6.67
2.	4.5	20	1,200	5,030	3,200	13,400	2.67	7.14
3.	4.5	20	1,200	5,030	3,350	14,020	2.79	7.73
4.	Q	30	1,250	5,230	3,750	15,700	3.00	9.00
5.	Q	30	1,250	5,230	2,750	11,500	2.20	4.84
6.	H	30	1,400	5,870	4,550	19,050	3.25	10.56*
7.	H	30	1,400	5,870	4,660	19,200	3.28	10.76*
8.	O	36	1,250	5,230	4,100	17,200	3.28	10.76
9.	O	36	1,250	5,230	4,125	17,250	3.30	10.89
10.	2.5	60	1,150	4,850	2,750	11,500	2.39	5.71
11.	2.5	60	1,150	4,850	2,900	12,100	2.52	6.35
12.	M. H.	14	1,200	5,030	3,100	12,970	2.58	6.66
13.	M. H.	24	1,200	5,030	3,800	15,900	3.17	10.00
14.	H	10-12	1,200	5,030	4,100	17,200	3.42	11.70†
15.	H	10-12	1,200	5,030	4,350	18,200	3.62	13.10†

*Wire netting. †Vulcanized rubber.

The wheels were held between two collars, each 6⅛ ins. in diameter and concaved, so as to bear only on a ring ⅝ in. wide at the outer circumference. The method of testing, and the apparatus used were precisely similar to those described in the paper on "The Bursting of Small Cast-iron Flywheels" in Vol. xxiii. of the Trans. Am. Soc. M. E. to which reference is here made for illustrations of the apparatus. The table shows the results of the experiments in detail, and needs but little explanation.

Wheels numbered 1, 2, and 3 were of one make, and show a remarkable uniformity in strength. Nos. 4, 5, 8, and 9 were all made by one firm; the two latter wheels were of finer grain than the others, and show a correspondingly greater strength. Nos. 6 and 7 contained a

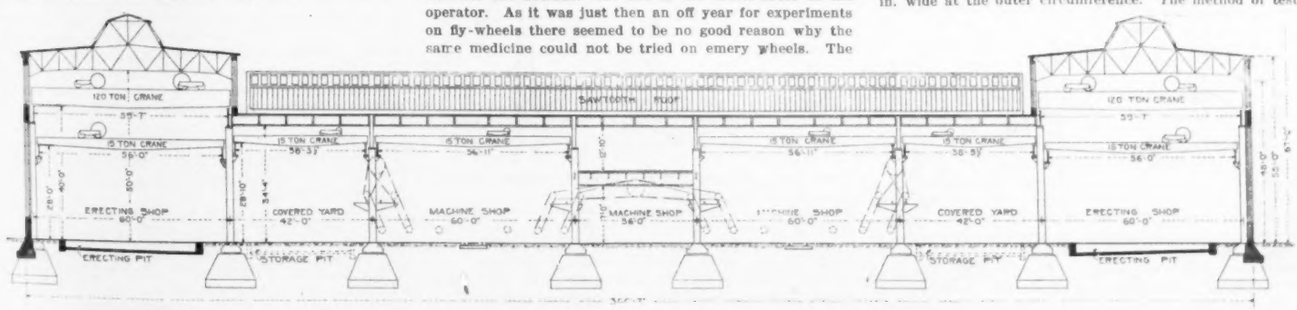


FIG. 4. CROSS-SECTION OF MAIN LOCOMOTIVE SHOP.

*Abstract of a paper presented at the Saratoga meeting of the American Society of Mechanical Engineers, June 23-26, 1903.

†Professor of Mechanical Engineering, Case School of Applied Science, Cleveland, O.

layer of brass wire netting imbedded in the emery, and were about one-third stronger than the average of the ordinary wheels. The wheels numbered 10 and 11 were the weakest among those tested, but have an apparent factor of safety of between five and six. Nos. 12 and 13 of still another make burst at about the average speed. Wheels Nos. 14 and 15 were so-called vulcanized wheels, containing rubber in the bond, and intended for particularly severe service. These showed, as was expected, rather more than the average strength.

An examination of the last two columns in the table shows that the wheels burst at speeds varying from two and one-quarter to three and three-quarters the working speed, and accordingly had factors of safety, varying from 5 to 13. It is then apparent that any of these wheels were safe at the speed recommended, and would not have burst under ordinary conditions. At the same time, considering the violent nature of the service and the shocks to which they are exposed, it would seem that the factor of safety for emery wheels should be large. In comparison with those generally used in machines, a factor of 8 or 10 would seem small enough. It may also be said that such a variation in strength between wheels of the same make and grade, as, for instance, that between Nos. 4 and 5, indicates a lack of uniformity which causes distrust.

The fractures were in the main radial, the wheel splitting in three, four or five sectors as might chance. It may be assumed that these radial cracks started from the rim where the velocity and stress were greatest, but it is a fact worthy of notice that in nearly every instance the cracks radiated from points where the lead bushing projected into the body of the wheel.

THE WORK OF THE TWENTIETH CENTURY ENGINEER.*

The great result of engineering is this: Engineering increases Efficiency. It provides the instruments and the means and the methods by which the results of human activity are enormously increased. It increases the work a man can do; it increases the wealth a nation can produce; it increases comfort and well being; it gives larger and broader life. The building of a new bridge, or of a larger or a more efficient engine, or of a more convenient office building are not merely individual things to contribute to the convenience of a few persons; still less are they to be considered merely as the means by which the engineer or the builder may derive remuneration. They are part and parcel of the great mechanism, of the intricate machinery of our modern life, and they are as essential to its existence and its prosperity as are the buildings and power plant and tools in a great machine shop to the workmen who are making locomotives. Consider it in this light, young men, and the profession you have chosen is one whose calling is high and whose responsibilities are large. Do not lose sight of this broader view, do not become so absorbed in minutiae or in details that you miss the inspiration which comes from realizing the part which your profession and your work is to fulfill in promoting onward progress, for we are now "in the throes of yet greater things."

One of the important phases of the new order of things is the aggregation and combination of industries and of capital which characterizes every branch of business. It has been asserted that this is subversive of individual independence, that it restricts individual aspiration and advancement, that it is a dark cloud in the horizon of the college graduate.

I have seen recently an extract from an address by Mr. James B. Dill at the University of Minnesota which deals with this question. He said: "I believe that the tendency to organization, to combination has put a demand on the college trained mind, has put a premium upon the services of such men and has made it easier than formerly for the college graduate to get started and to succeed in the world. . . . The college man has come to the front with his trained mind and his trained body, and to-day is pushing off the throne those men who have not had the advantages of a college training."

There is another aspect of the modern movement in which the tendencies are not so clear. We know that civilization and co-operation go hand in hand. We recognize the fundamental economics which are the inspiration and the justification of the corporation as a financial and industrial institution. It is coming to be generally believed that in so far as its financial and commercial and engineering aspects are concerned the trust is sound in theory and that if it fail it is not because of wrong principle but through misuse and abuse of that principal. But there is an element in the problem aside from that of finance, aside from that of engineering and of production, it is the human problem, the problem of relations between men. I apprehend that there is a general feeling that the large corporation and the trust are not theoretically sound from the social standpoint, that although they may lead to economics in production they do not conduce to general individual advancement and personal freedom. It is felt that the tendency to elevate a few leaders and to group men into masses and to treat them in the aggregate and not as individuals.

These general questions are not separate and apart from the field of the engineer They are vitally connected with his work and his interests. He who has paved the way by development of material things for combination in financial and commercial and industrial affairs which in turn have led to new social problems, has assumed new relationships and new responsibilities. He has furnished the machinery and the material appliances and facilities on which the great interests of the present are based. May not the methods and the principles and ideals which have proved successful in dealing with material things be applied also to those organizations which deal with men? Has not this material basis of modern life been more successful and skillfully and completely established than its financial and political and social relationships? It is unjust distribution of wealth and speculation, it is corrupt in municipal and general government, it is conflict between laborer and employer that disturb and threaten. The engineer has learned the value of Truth. He knows and he respects physical laws. Effects follow causes quickly; failure is the certain consequence of false data or bad methods. But human affairs are more complex, failure cannot be so readily traced to its cause, the Truth is not so evident, nor is it so respected, yet after longer time it is just as surely final. The ideal underlying engineering work is efficiency—the production of the maximum result with the minimum effort. The prevailing motive elsewhere is selfishness. Trace them back to their ultimate causes and you will find that the real danger in business is causes which come from greed,and the real cause which underlies the conflict between labor and capital is selfishness. The aim of the old time military engineer was destruction, the object of the modern engineer is construction. Engineering became a new factor in world history when it severed itself from warfare. Who can picture the transformation when the principles of war and of selfishness in business and in social affairs shall be supplanted by higher and nobler and better motives? Then we shall find that the Golden Rule—the law of Love—and the law of Efficiency are one and the same.

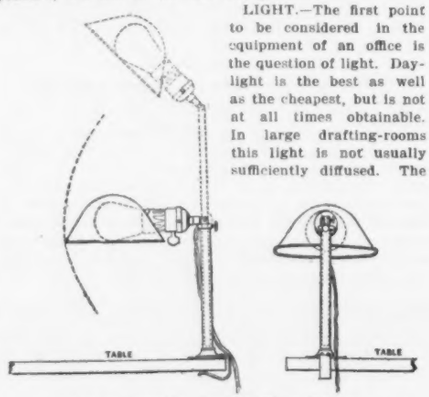
*Extract from an address by Chas. F. Scott, President American Institute of Electrical Engineers, at the Commencement exercises of Stevens Institute of Technology.

DRAWING OFFICE EQUIPMENT.*

By John McGeorge,† M. Am. Soc. M. E.

There are many prominent engineers, and some of the very best ones, too, who look upon drafting as merely a means to an end, and think that the end which they seek is so much more important than the means, that they often think of drafting as too trivial to give it their attention. We estimate that from forty-five to fifty million dollars is paid to draftsmen in salaries in this country in a single year, and we cannot understand why so little attention has been given generally toward an equipment which will enable the men commanding these aggregate salaries, not only to produce drawings in the cheapest way possible, but also in the best way possible.

LIGHT.—The first point to be considered in the equipment of an office is the question of light. Daylight is the best as well as the cheapest, but is not at all times obtainable. In large drafting-rooms this light is not usually sufficiently diffused. The windows should be as high and as near the ceiling as possible, so that the interior of the room may receive light. The man next to the window should only have control of the shades covering the lower half of the sash, and the shades, both upper and lower, should be translucent. There are only two methods of artificial lighting which have proved to be perfectly satisfactory. The one is where arc or Nernst lights are used and the light reflected from them against dead white ceilings and walls. This gives good general illumination, which, if properly done, will dispense with individual lights. The writer thinks that if the Nernst 3 or 6 glow lamps were provided with shades underneath, throwing the light to the ceiling, these shades made just translucent enough so as not to be a dark spot in the room, the walls and ceilings painted a dead white, then we would have a perfect light, soft, agreeable and without shadows; in short, a light closely approaching daylight.



Light Bracket for Drafting Table.

The other method which has given satisfaction is the individual lamp for each board. These should be made adjustable, and there are quite a number of methods in use for doing this. We show in Fig. 1 a sketch of a holder which we have found very satisfactory, and which is properly the simplest method. Our temporary offices are now fitted with Nernst lamps, suspended from the ceiling at intervals of 6 to 8 ft. apart, but when used in this way these lights cast shadows, and are not satisfactory.

VENTILATION.—The second important consideration is that of ventilation. No draftsman can do his best work without an abundant supply of fresh air. This is a matter which is receiving more and more attention in the designing of schools and public buildings generally, and it is beginning to receive considerable attention in offices. We change the air in our drafting-room as frequently as possible by means of an exhaust fan, but even when this is done we believe that from the standpoint of fresh air required, draftsmen should have at least double the space we have allotted to them. High ceilings are an aid in this matter as well as in the matter of light

DESKS.—In the matter of desks the bulk of offices seem to be very neglectful of the fact that good convenience tend to good work. A very large proportion are still fitted with nothing more than a pair of trestles, or a flat-top table, and a flat board with a tee-square. We (the Wellman-Seaver-Morgan Company) have been using a large number of Svenson boards, which have a frame carrying a parallel ruler on the Bergner principle, and in which frame can be placed a loose board, thus enabling a number of different drawings to be worked on without disturbing the paper on the board. The Svenson board can be placed at 60°, 45°, or flat (the ruler being balanced), and this to any one troubled with bilious headaches is a great blessing. This board was supplied with a convenient desk below, and we also provided a chest of drawers to the left of the draftsman, the top of which served as a reference table, and the drawers provided ample room for reference drawings. In fact, we might say, too ample, as we had provided too many drawers, and whenever drawings were lost it required a great deal of work to find them.

While sufficient room should be given to each man for reference drawings and for partially completed drawings, it is undoubtedly a mistake to give more than enough drawers for this purpose, and in our new office we shall give each man two drawers for drawings, together with a good drawer for his tools and another for books and notes. We found several objections to the use of vertical boards for average size drawings, and later we designed a table which could be adjusted in height and slope and used it in connection with the tee-square, and later on with the Universal Drafting Machine, of which I shall speak further on. We found three objections to the vertical table, two of which are made by the draftsmen themselves, and one by the superintendent of the drafting-room. Many men object to having to hold their arms up about even with their shoulders all day long, and then again the vertical drawing board does not give the man the opportunity to have his reference drawings right around him as the horizontal board does. The superintendent objects to them on the ground that they divide the drafting-room off into stalls.

A very practical question arises right here as to the number of square feet of space to be given to each man. There are three factors entering into this question. First, the convenience of the man, allowing ample room for reference drawings, etc.; second, ventilation, and, third, sufficient room so that those supervising the work can get around the office without disturbing the men in passing. We believe that it would be good business policy to allow 100 sq. ft. for each man. The American Bridge Co., employing hundreds of men, allows considerably more space than this.

In regard to sanitary arrangements, the toilet-room should be immediately off of the drafting-room. We have provided one closet to each 15 men, and wash basins in the same proportion.

The recent developments in electric blue-printing have been a great relief to many of the large offices in the country, and as they make the blue-printing entirely independent of the weather they are being very generally adopted.

DRAFTING MACHINES.—I have referred to the Universal Drafting Machine, and desire to bring to your notice two forms of these machines. They are, in my opinion, the most radical departure which has been made in the drafting line, and I believe they are a very important aid to the draftsman. I am very much interested in this device, as it was designed (invented might be a better word) in our office. It was not a chance or lucky thought, as the inventor, Mr. Charles H. Little, has conferred with me many times during the past few years in regard to improvements in the drafting-room. Mr. Little had also invented a number of other very useful ap-

*Abstract of a paper presented at the Saratoga meeting of the American Society of Mechanical Engineers, June 23-26, 1903.

†Chief Engineer, Wellman-Seaver-Morgan Co., Cleveland, O.

pliances before he brought out this machine, and I sincerely hope and expect that we shall hear from him again.

This machine is doing all that he promised for it, and something more. The machine is so exceedingly simple that it scarcely needs description.* It is based on two fundamental ideas, one that all angular work must be as readily put in as straight work; and second, that we must enable the draftsman to draw and scale a line with the same edge at the same time. This applies in straight work as well as in angular work, and eliminates considerable erasing, as well as the constant changing from one tool to another. In short, work that formerly required two tools to be used on each line now requires only one, saving the time necessary to change from one tool to another. The protractor used with this machine also has a new feature, in that it is provided with spring stops for the angles most frequently used, and at the same time it may be clamped to any angle.

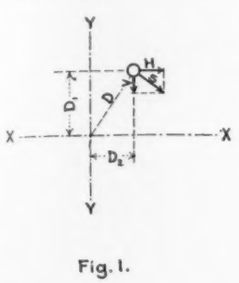
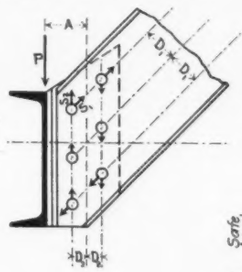


Fig. 1.



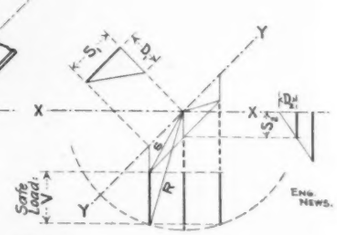


Fig. 4.

In actual tests made by Mr. Little he has demonstrated on both a typical mechanical and a typical structural drawing that the saving of time is very nearly the same, and amounted to 33⅓% in these two tests which were made to determine the efficiency of this machine. Some time since Mr. Little sent out a large number of letters to many of the leading concerns using this device, asking their experience with particular reference to the time-saving feature. He received replies varying from 10% to as high as 50%, and many firms stated that they could not say what percentages they saved, as they had not given the matter close enough attention, but that they were satisfied that the saving was very considerable.

One of the problems which it has been necessary to contend with in this device is the extreme accuracy required. For instance, machines have been tested in which there was a variation of less than 1-100-in. in 24 ins. As the bearings are 3 inc. c. to c., a variation of 1-1,000-in. in these eight bearings would give a variation at the end of a 24-in. straight-edge of 1-125-in., and this 1-1,000-in. divided by eight bearings would make 1-8,000-in permissable in each bearing. That this is obtained in large quantities of machines is a rather unusual condition, and the question arises as to what effect wear will have on the accuracy of the instrument.

In reply to this question I would say that the bearings are all hardened and ground, and that the pressure and speed, which are the conditions which produce wear, are almost nothing in this device. We have had one in use for some 18 months, which was an experimental one and had straight, soft bearings, and these bearings do not, although they were soft, show perceptible wear after use for this length of time. We therefore conclude that the hardened bearings will last indefinitely. Another question which came up was whether or not the scales would wear when used as straight-edges, particularly at the parts of the scales which were most used. We find that the graphite provides a lubricant along the edge of the scale, and they showed no perceptible wear after continued use.

A second form of this device is what is called the Rapid Sketching Device. It is similar in principle to the drafting machine, but being very much smaller and used merely for the purpose of sketches, it has but one scale instead of the square as used in the drafting machine. This single scale has a free throw of 90° between stops, and this 90° can in turn be set at any angle.

ADMINISTRATION.—In conclusion I would draw attention to one feature we have just gotten in good working shape, although it is more strictly a question of management than equipment. We have found that it is a great advantage to separate completely the executive management of the drawing-room from the engineering oversight, more especially as the drawing-room has changed into the engineering office of the works in every respect. Not only are drawings made there, but all orders are made out for material, etc., and oversight is exercised over the outside engineers, of whom we have two classes, engineers in charge of work, and erectors putting up machinery. So that we have appointed a superintendent of the drafting office, whose business is to take entire executive charge of the men, looking after all time, salaries, drawings, blue-prints, requisitions on the purchasing department, the hiring of men, etc., leaving only the actual engineering questions to be handled by the engineers, of whom we have several. The office itself is divided into departments, each of which has a foreman (who is also a good engineer). So that the superintendent is responsible for the smooth running and the getting of the work through the office; whilst the different engineers are responsible for the engineering side of the question. This arrangement is working very well, and will work much better as all parties come to understand thoroughly just where their duties end.

*This machine was described in detail in Eng. News, May 15, 1902.

RIVETED CONNECTIONS IN TORSION.

By Wallace E. Belcher.*

The interesting case of a riveted connection which is resisting both a shear and a tendency to rotation was discussed in Engineering News of May 21, and was solved by the application of polar moments of inertia. In resisting the moment, each rivet was used as acting with an arm equal to its distance from the center of gravity of the group of rivets, and as taking a stress proportional to this arm at right angles to it. In the usual riveted connection, however, neither this distance nor direction can be taken directly from the detail drawings, which usually show dimensions in two directions at right angles to each other.

The writer would suggest that the problem is capable of a correct theoretical solution using these given distances and the equation of moments.

Under Fig. 1 of the article mentioned, it is stated correctly that the polar moment of inertia is equal to the sum of the moments of inertia about the axes X X and Y Y, thus, $I_p = I_x + I_y$.

Considering a force instead of an area we have a similar relation; the moment about the point 0 is equal to the sum of the moments about the axes X X and Y Y. These moments may be written if we divide the stress in each rivet into components parallel to the X and Y axes, respectively. That is, referring to Fig. 1,

$$M = S \quad D = H \; D_1 + V \; D_2.$$

Having located the center of gravity of the group of rivets and treating each component as proportional in amount to the perpendicular distance from it, the sum of the moments of these components will be the total resistance of the connection.

In Fig. 2 let P represent an acting force and A its arm. D_1, D_2, D_3, etc., are the distances from center of each rivet to the center of the group, in directions parallel with the dimension lines. S_1, S_2, S_3, are the components of the rivet stress, perpendicular and proportional to D_1, D_2, D_3, etc. Then,

$$M = P\,A = S_1\left\{\Sigma\frac{D_1}{D_1}\,D_1 + \Sigma\frac{D_2}{D_1}\,D_2 + \Sigma\frac{D_3}{D_1}\,D_3\right\}$$

$$= S_1\,\frac{\Sigma\,D_1^2 + \ldots\ D_3^2}{D_1}$$

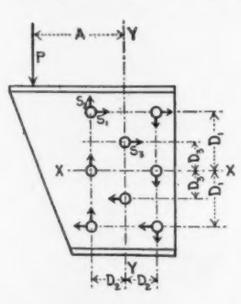
$$= S_1\left\{\frac{4\,D_1^2 + 6\,D_2^2 + 2\,D_3^2}{D_1}\right\}.$$

The only unknown is S_1; this value should be well below the rivet value.

Drawing a right triangle with D_1, the longest arm, as the base, and S_1 as the altitude, we may lay off any D along the base and find the corresponding stress as the elevation of the hypothenuse. With center at the origin, draw an arc with radius R, equal to the maximum allowable stress on the rivet. Projecting the two moment components of the rivet, the resultant S is shown. From its extremity, the line drawn to the rivet circle, parallel to the acting force, gives the available strength remaining to support the load. Calling the smallest remainder found V, and considering the direct load as equally distributed upon all the rivets, the allowable load is equal to V times the number of rivets.

If, as in Fig. 3, the line of action of the force is not parallel to the X or Y-axis, the diagram is similar, except that V will be inclined instead of vertical, to correspond with the direction of the force.

If the dimensions of the joint detail are given in an oblique direction, as in Fig. 4, for example, the axes X X and Y Y must be drawn parallel to the gage lines. The triangle used to find the value of S_1, S_2, S_3 is most conveniently placed as before with its base in a line through the origin perpendicular to the axis.



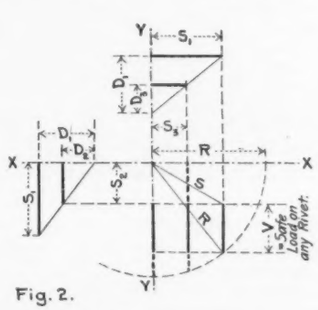
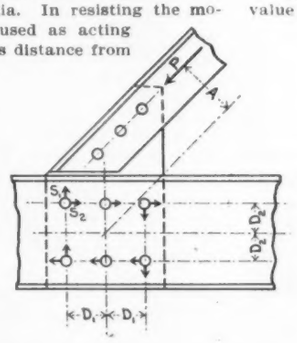


Fig. 2.



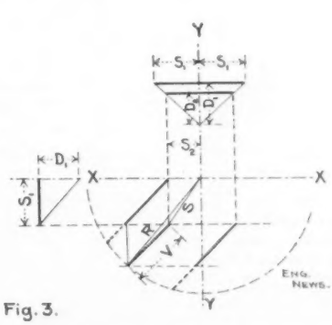


Fig. 3.

The stress in the rivet has been assumed as uniformly distributed over its cross-section. The uncertainties which are necessarily introduced by ordinary shop work, make any calculation give only a good approximate value. This method outlined has always seemed to the writer to be on the safe side.

*Niagara Falls Power Co., Niagara Falls, N. Y.

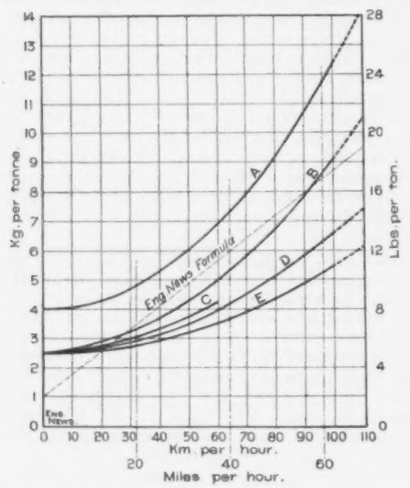
GERMAN TESTS OF RAILWAY TRAIN RESISTANCE.

A recent series of tests on train resistance at different speeds is summarized in a diagram which we reproduce herewith. The experiments were carried out on the state railways of the kingdom of Hanover, Germany, and were made by Professor Albert Frank, of the Hanover Technical College, who reports on them in a recent issue of the "Zeitschrift des Vereins Deutscher Ingenieure." As the coasting method was used in making the tests, it might be interesting to see

whether the results obtained were a fairly uniform and consistent series, or varied considerably. But unfortunately this is impossible, because the author gives only the curves and equations which he deduces as being closely accurate representations of the results. In any case the results would not be accurately applicable to American conditions since the tests were made with German locomotives and cars, which differ in many important features from those used in this country.

The track on which the tests were made was a down grade of one-third to one-half of 1%. The method used was to bring the engine or train up to speed and then let it run down grade with steam shut off; the time required to traverse successive stretches of 200 m. was noted by stop watches. Curves, when such were passed, were allowed for, in calculating the results, by a specially developed formula.

The first part of the tests was made on an engine without a following train. The engine was brought up to speed, steam was shut off and the valve gear thrown out, and the engine allowed to coast down hill. Two different engines were experimented with, both being eight-wheel two-coupled (220) compounds with swiveling leading truck; they differed in weight, one weighing 171,000 lbs. with tender, while the other weighed 193,000 lbs. The test was then extended to determine the amount of loss caused by the pistons pumping air. An engine of similar type to the two preceding was used in a duplicate set of tests after its steam valves had been removed. The results, the tractive resistances in kg. per metric ton for different speeds, were expressed by equations, which we have converted into English measures as follows:



Tractive Resistance of Locomotives and Trains from Frank's Experiments.

A. Compound Passenger Locomotive, Drifting: $R = 8.0 + 0.0043\ V^2$.
B. Locomotive Under Steam: $R = 5.0 + 0.0034\ V^2$.
C. Freight trains, mixed loaded and empty cars: $R = 5.0 + 0.0026\ V^2$.
D. Passenger Trains, weight of single car about 15 tons: $R = 5.0 + 0.0020\ V^2$.
E. Passenger Trains, weight of single car about 30 tons: $R = 5.0 + 0.0015\ V^2$.

For engines with steam shut off (pumping air), the resistance in lbs. per ton is

$$R = 8.0 + 0.0043\ V^2, \qquad (1)$$

while for the engine in which the steam valves were removed

$$R = 5.0 + 0.0034\ V^2. \qquad (2)$$

When an engine is running under steam, there is no pumping of air in the cylinders, and its tractive resistance is therefore expressed by the equation (2) given above.

Following these tests with engines, similar tests were made on entire trains. Passenger equipment only was used, including two types of cars which weighed, respectively, 15 tons and 30 tons each. Trains were made up in varying lengths, from one car behind the tender upward to regular service lengths of train. The total train resistance calculated from the observations was then diminished by the engine resistance, the latter being obtained from the results of the previous tests; the difference, representing the total resistance of train behind tender, was then reduced to lbs. per ton. The expressions deduced are the following (converted to English measures): For trains made up of cars averaging 15 tons each,

$$R = 5.0 + 0.0020\ V^2, \qquad (3)$$

while for trains in which the cars average 30 tons each, the resistance is lower, thus,

$$R = 5.0 + 0.0015\ V^2. \qquad (4)$$

The tests did not extend to freight equipment, but Professor Frank deduces by theoretical reasoning several formulas applicable to freight trains. He assumes that the difference in the tractive resistance of freight and passenger trains is produced entirely by the difference in the areas subject to air resistance. On this basis he deduces equations varying from

$$R = 5.0 + 0.0014\ V^2$$

for full, loaded freight trains, to a mean value of

$$R = 5.0 + 0.0026\ V^2$$

for mixed trains of loaded and empty cars. These expressions apply to the train behind tender.

All the equations given in the preceding are in English measures, i. e., R = tractive resistance in lbs. per ton, and V = speed of train in miles per hour. They are represented graphically on the diagram herewith, the co-ordinate scale being indicated in both English and metric measures. For comparison we have plotted on the same diagram the well-known formula advanced a number of years ago by Engineering News, viz.: $R = 2 + \frac{1}{4}\ V$.

It should be remarked that the form of equation used by Professor Frank to express the variation of tractive resistance with speed, namely, $R = a + b\ V^2$, is based on theoretical considerations. He holds it to be proven that the whole resistance of a train is made up of two parts, one of which is constant while the other varies as the square of the speed. The former component is due to the various frictions, the latter to wind resistance and to the effect of vibration and shocks. Since he thus assumes a form of equation in advance, it would be valuable to know whether the results of his experiments justified him in this. As already stated, there is nothing given on this point, in the article from which we draw, than the statement that the results were closely fitted by the equations given. Nothing is said in the article on the state of the weather and wind, or whether they were allowed for in any manner.

EXPERIMENTS ON THE STRENGTHS OF DIFFERENT MAKES OF HOISTING HOOKS.*

By John L. Bacon,† Jun. Am. Soc. M. E.

The following are some results obtained from experiments which had in view a comparison of the strengths of hooks bent out of round stock, and hooks shaped according to Towne's formula, and also the effect of case hardening, or carbonizing, upon the strength of the above hooks. No attempt was made at mathematical analysis, the object being experimental data. The general shape of the hooks tested is shown in Fig. 1. The eyes were welded, and pains were taken to have the lower curved parts of the hooks to be compared, alike as near as possible.

One of the conclusions drawn from the experiments was, that if the hook was properly shaped between the points A and B, Fig. 1, the shaping of the rest of the hook had very little to do with the strength; the shaping of the rest of the hook having more to do with the "hang" than the strength. Of course the critical part for strength lies at about the point C, the shape of the lower part merely determining the point at which the load will be applied. All of the hooks tested failed, either by bending or breaking, at about C.

When testing, working conditions were reproduced as nearly as possible. The hook was suspended by a loop of round iron run through the eye, the ends of the loop being gripped in the upper jaws of the testing machine. A long link of round iron was put over the hook and through the lower head of the machine and a round bar passed through the lower end of the link under the head. This arrangement left the hook free to adjust itself to the strain in all directions.

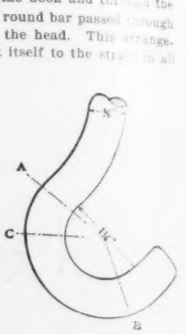


Fig. 1. Sketch Showing Shape and Dimensions of Round Hooks Tested at Lewis Institute, Chicago, Ill.

Some of the samples were case-hardened or carbonized. These were heated with granulated raw bone. The ⅝-in. hooks were hot for about eight hours and the 1¼-in. hook for about nine hours. The depth of penetration of carbon, or thickness of the carbonized coating of the mild steel was about 1/16 in. The ⅝-in. hooks were all made from one bar of mild steel and both 1¼-in. hooks were made from one bar. In the following table the word "carbonized" is used to designate the hooks which were treated as described above. Those marked simply "carbonized" were allowed to cool in the box in which they were heated; those marked "annealed" were afterward annealed, and the ones marked "hardened" were hardened in the usual way.

Following are the more important data from the experiments:

Mark.	Kind of Hook.	Size of Stock. Inches.	Bend Started at	Max. Load. Bent.	Max. Load. Broke.	T. S. of Bar.
4	Plain	⅝	2,500	3,000	....	62,150
5	Plain	⅝	2,400	3,300	....	"
3	Plain—Carbonized and Hardened	⅝	4,000	....	4,200	"
1A	Plain—Carbonized and Annealed	⅝	2,750	....	2,900	"
2A	Plain—Carbonized and Annealed	⅝	2,600	3,200	....	"
2A	2A—Bent into Shape and Hardened	⅝	5,000	....	5,200	"
X	Carbonized and Hardened—Towne's Shape, Fig. 2	⅝	....	....	3,000	"
XX	Carbonized—Towne's Shape	⅝	2,800	....	3,200	"
-X	Towne's Shape—Untreated	⅝	3,000	3,500	....	"
C	Plain—Carbonized and Annealed	1¼	9,000	....	13,500	"
T	Towne's Shape—Untreated	1¼	6,000	13,000	....	"

Fig. 2 gives the dimensions of the flattened hooks. These hooks were made to conform as nearly as practical to Towne's formulae. The other hooks, bent into shape without any flattening, had the same inside curve as the flattened hooks. The flattened hooks all gave way by compressing the metal shown by the shaped area. This was easily determined, as the scale at this point cracked off and was undisturbed on the other parts. All of the hooks which failed by bending stood a much higher load after the bend started; or, in other words, the hooks would stand a heavier load after they were partially straightened out, due, probably to the fact that as the hook straightened, the leverage of the load was decreased.

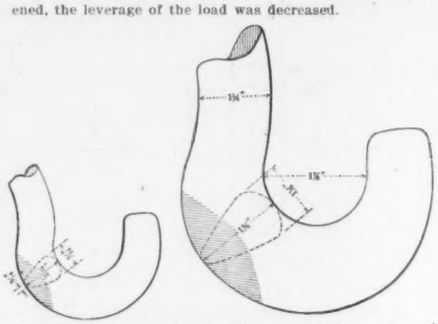


Fig. 2. Sketches Showing Shape and Dimensions of Flattened Hooks Tested at Lewis Institute, Chicago, Ill.

The above data would seem to indicate that a hook made from round iron and carbonized, is about as strong as the same shaped hook flattened according to Towne's formulae, while a plain hook carbonized and hardened is from 40% to 50% stronger than either of the other two.

The following may prove interesting as showing that the untreated hooks stand greater strains after they start to open. The detail report of the test on hook T was as follows: Very slight opening at 6,000 lbs. load; open scant 0/32-in. at 8,000 lbs.; strong 1/32-in. at 9,000 lbs.; 1/16 in. at 10,000 lbs.; ⅛ in. at 11,000 lbs.; would not sustain load of 12,000 lbs. any length of time, and opened rapidly at 13,000 lbs. After the above test, and without disturbing the hook in the testing machine, a load of 13,000 lbs. was applied. The hook carried this load without showing any signs of further opening for about 15 days. At the end of that time the load was increased and the hook straightened almost to a right angle, after which it held a load of 15,500 lbs.

*A paper presented at the Saratoga meeting of the American Society of Mechanical Engineers, June 23-26, 1903.

†Instructor in Forge Work and Machine Design, Lewis Institute, Chicago, Ill.

PLACING A 6-FT GATE VALVE FOR THE CHICAGO WATER-WORKS.

The largest gate-valve in the West is a 6-ft. valve recently installed in Chicago, and that city has a new satisfaction in knowing that she now possesses as large a valve as any other city in the United States, and doubtless any in the world. This valve is placed in a 6-ft. brick tunnel at the Chicago Ave. pumping station of the city water-works system, and controls the supply from the lake tunnel to the new pumping engines. It is at the bottom of a 12-ft. shaft, 90 ft. deep, the joint between the flanges of the valve casing and the brick lining of the tunnel being made with cement, while the body of the casing is embedded in concrete. The clear opening is 6 ft. in diameter, and the valve is operated by two 3½-in. bronze stems fitted with gear wheels on top. The driving pinion engaging with these wheels is on the end of a rod which extends to the surface, passing through a standard on the engine room floor and operated by a hand wheel. It requires 585 revolutions of this wheel to open the valve completely. It was at first proposed to operate the valve by a motor placed in the shaft, but it was feared that moisture and lack of use might cause some injury rendering this inoperative when needed.

HANDLING A 6-FT. 17½-TON VALVE AT THE CHICAGO AVE. PUMPING STATION, CHICAGO.

The valve is about 10 × 4 ft. in horizontal dimensions over the casing, and its height is 18 ft. to the top of the central stem or rod shown in the cut. Its weight is 35,000 lbs. It was built by the Ludlow Valve Mfg. Co., of Troy, N. Y., and we are indebted to Mr. H. E. Keeler, Western Manager, for the photograph reproduced herewith, which shows the valve in position for lowering into the shaft.

The handling and setting of this large and ponderous piece was a matter of importance, and was entrusted to the Merchants Transfer Co., of Chicago, whose men are experienced in the handling of heavy articles, such as safes, etc. At the freight yards, the valve was moved on skids to a heavy truck, and hauled to the pumping station by eight or ten horses. Timber cribbing was built up on opposite sides of the shaft, and supported heavy timber beams which spanned the shaft. A platform of heavy timbers was also placed over the mouth of the shaft, and the valve was slid from the truck on skids and deposited in a horizontal position on this platform. From a hand capstan set in the street, two ¾-in. wire cables were led to sheaves attached to the cross timbers carried by the cribbing, and then down to two pairs of three-sheave blocks. To the hook of each lower block were attached chains passing round the body of the valve, as shown. The tackle being attached to the valve, it was raised, and the chains and tackle attached. When raised to a vertical position the platform was removed and the valve lowered directly into the shaft.

FAILURE OF A STEEL VIADUCT AT MINNEAPOLIS, MINN.

The approach to a large steel arch highway bridge at Minneapolis, Minn., forms also a viaduct, beneath which are the tracks of the Great Northern R. R. The viaduct was originally built by the railroad company and designed to support a live load upon a cedar block pavement weighing about 30 lbs. per sq. ft.

Recently the street grade was raised, and curved steel plates were laid upon the steel girders of the viaduct. Upon these plates an earth fill was made. The new pavement, the earth fill, and the curved plates weigh at least 200 lbs. per sq. ft. This earth fill appears to have become more or less watersoaked, thus adding still more to a dead load already twice as great as the original assumption of 100 lbs. per sq. ft. for live load. Furthermore, the water in this earth percolated through upon the girders beneath, and this, together with the acids from locomotive smoke coming from beneath, rusted the girders and their connections very badly. This corrosion probably reduced the strength of the girders by 30%.

To make a bad matter worse, the live load itself has been increased fully 50% over original calculations. Immediately after one of the heavy trolley cars had gone over the bridge, one of the girders gave up the struggle for existence. Fortunately no one was upon this section of the viaduct at the time, and it is remarkable that the collapse came after the girders had been subjected to a heavy load, and not during the time the trolley car was passing. It is probable that the steel had long been strained beyond its elastic limit, and had been slowly yielding at some section, so that the car was merely "the last straw," and after the critical point was passed, the excessive dead load served to carry the stretching to the point of rupture. In this it may have been aided by the jarring of the earth fill, due to a train passing beneath. At any rate the collapsing viaduct fell upon the rear car of the train, and injured a man standing on the rear car platform.

The collapsed structure was inspected by Mr. C. A. P. Turner, M. Am. Soc. C. E., shortly after the fall, and we are indebted to him for a description of the conditions which existed, and for the sketches from which our cuts, Figs. 1 and 2, were made.

Fig. 1 shows a column that supported the girder which broke along the line A A. Knee-braces, K, were riveted to the girders and to batten plates,

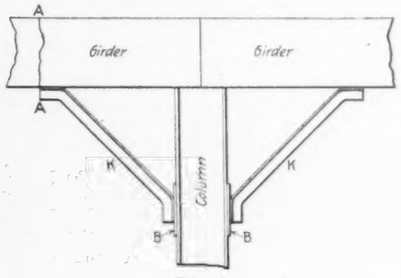


Fig. 1.

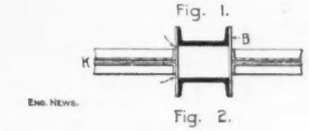


Fig. 2.

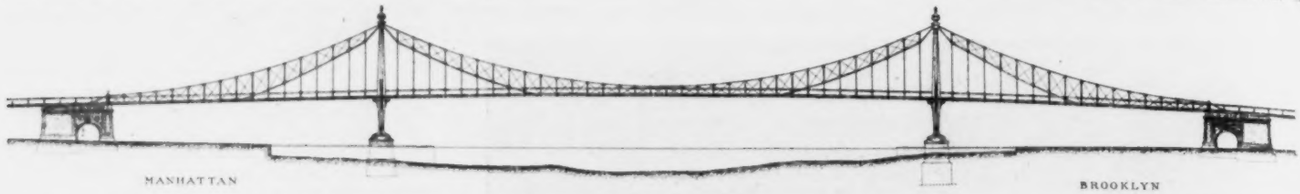
B; the battens being riveted to the column. The batten plates, B, in Fig. 2, was found pushed into the column, and sheared off at the lines indicated by the arrows.

In closing we may quote from the communication received from Mr. Turner:

> The knee brace sheared the batten plate on the column, and the bottom flange of the girder appears to have given way first through the holes of the knee brace connection. The design is open to criticism in failure to consider the effect of knee brace in design of girder and in the inferior connection at B.

SURVEYS OF THE CHICAGO & ST. LOUIS WATERway provided for in the last River and Harbor Bill, are being made by the United States Engineer Corps, along the course of the Illinois and Desplaines rivers. The proposed waterway is designed to have a navigable depth of 14 ft. A party of engineers and assistants, under the direction of a Board of Engineers composed of Col. O. H. Ernst, M. Am. Soc. C. E., Col. C. J. Allen and Major Thomas L. Casey, U. S. Army, and in charge of Mr. J. W. Woermann, M. Am. Soc. C. E., U. S. Assistant Engineer, began work at the mouth of the Illinois River last October. There were only a few parties at work during the first month, but the force was gradually increased until

it comprised one triangulation, one precise level, five topographical, one hydrographical, and one Y-level party, and an office force of three draftsmen and one clerk. The total force of about 70 men has been quartered on boats equipped for the purpose. The work was pushed steadily without interruption until the first of March, when high water flooded the bottom lands, and necessitated laying off a large part of the field force. All of the field work, excepting borings and discharge measurements, has been completed up to Montezuma, a town about 50 miles above the mouth. From this point to Pekin, the present location, it has only been practicable to carry on the secondary triangulation, the precise and Y-levels, and the topography of the higher land adjoining the bluffs. The stadia notes have been reduced each night, and within a few days plotted on protractor sheets, so that in case of any discrepancy it is discovered while the party is still within reach of the work in question. The scale of the maps is 1 in. to 400 ft., and the contour interval is 1 ft. A small force is at work in the Peoria office, transferring the work from the field sheets to the final map. The secondary triangulation and levels will be continued up the valley, and when completed will constitute connecting links between those of the Mississippi River Commission and the Lake Survey. As soon as the bottom lands are again dry the remainder of the field force will return to Montezuma, and complete the topography and hydrography, together with the tertiary triangulations and Y-levels. Up to the present time about 290 square miles of topography have been taken, and 1,100 ranges sounded, all of which has been reduced and plotted. The borings will be commenced as soon as the necessary equipment is prepared.



OUTLINE ELEVATION OF PROPOSED MANHATTAN SUSPENSION BRIDGE WITH EYE-BAR CABLES, OVER THE EAST RIVER, NEW YORK CITY.

COMPARISON OF EYE-BAR CHAINS WITH STEEL-WIRE CABLES FOR THE MANHATTAN BRIDGE.

About three months ago Hon. Seth Low, Mayor of New York city, appointed a board of eminent bridge engineers to examine the plans for the new Manhattan suspension bridge in New York city, designed by Mr. Gustav Lindenthal, Commissioner of Bridges. The board consists of Messrs. George S. Morison, Theodore Cooper, C. C. Schneider, Prof. Mansfield Merriman and Henry W. Hodge, and a preliminary report was submitted by it on March 9 and was published in Engineering News of March 12. The final report is delayed by the serious illness of the Chairman, Mr. George S. Morison, but will probably soon be forthcoming.

In the meantime a statement has been prepared by Mr. Lindenthal for the board on the comparative merits of eye-bar chains and steel wire cables for suspension bridges, and we have been furnished with the following extracts from this statement for publication:

The comparison of eye-bar chains with steel wire cables is based on the design and system of stiffening adopted for the Manhattan Bridge. The eye-bars are assumed to be of annealed nickel steel, having an elastic limit of not less than 48,000 lbs. per sq. in., and an ultimate limit of not less than 85,000 lbs. The eye-bars will be 18 ins. wide.

The steel wire for the cables is assumed to have an elastic limit of not less than 150,000 lbs. and an ultimate limit of not less than 190,000 lbs. per sq. in. for gage No. 7 B. G.

The extreme live load of 16,000 lbs. per lineal foot of bridge, or 4,000 lbs. per ft. on each chain or cable, as recommended by the Board of Engineers, will strain the eye-bars to 39,000 lbs. per sq. in. But that load could be produced only by special preparation and may never occur. The so-called working load is assumed at half the extreme load, and may happen a few times a year. The four steel wire cables will each be assumed to be strained from the same live load to 84,000 lbs. per sq. in. In the eye-bars and in the wire cables the maximum stress will therefore approximate from 44 to 46% of the ultimate breaking strength. In both the maxima are far within the elastic limit.

That the working stress from live load may be assumed much higher in large heavy structures than in lighter structures of smaller span is a principle too familiar for discussion. It is the universal practice to express the degree of safety of a structure in terms of the breaking strength (or ultimate limit) of the material. It is, however, well understood that the maximum working stress must under all conditions be well within the elastic limit of such material. There are good reasons for adhering to this practice in comparing the strength of eye-bars and of steel wire. The differences in the physical condition of these two materials are radical, and a comparison of strength, based on their elastic limit alone, would be misleading.

A steel eye-bar, which has been annealed, is in a natural physical condition, not materially affected thereafter by reheating. But if such an eye-bar is strained beyond the elastic limit, say to 70,000 lbs. per sq. in., and if then the strain be reduced to say 23,000, which is within the elastic limit, and allowed to rest with that strain, or without any strain, then in that case, as we know from tests, both the elastic limit and breaking strength of the steel are considerably increased. The steel has been elongated and received a set. A higher tenacity has been artificially imparted to it by alternating over-stress with rest. This is precisely the process by which a higher tenacity is produced in the wire. But this higher tenacity in both the bar and the wire can be annulled by reheating or annealing, which brings the metal back to its first natural condition.

The annealed eye-bar may be exposed to accidental heating without material injury. The wire cannot be so exposed. The annealed bar will elongate 9 to 10% before breaking; the wire only 3 to 4%. The degree of safety of both is therefore not alike under all conditions, although the modulus of elasticity is practically the same in both materials.

The margin of strength between the maximum working stress (which, as already said, must be within the elastic limit in any event) and the breaking or ultimate limit, constitutes therefore that reserve strength in the eye-bar and in the wire which, while differing in character and behavior, is otherwise of equal protective value against such local higher or uneven stresses as may be caused by unavoidable imperfections of work or by unforeseen accidents.

It is considered good practice for eye-bars in a chain of accurate workmanship and having a large margin between the elastic limit and the breaking limit, to be strained much nearer to the elastic limit than wires in a cable, where such margin is less than half as large, and where the same accuracy of adjustment and workmanship is not so certain. The eye-bar with an elongation three times greater than that of wire before breaking would, moreover, give earlier warning of failure, if failure could ever come through overloading, which, under the assumed conditions, is impossible.

Wire is the only practicable material for very long spans. In fact there is no choice there. But in spans of the length of the Manhattan Bridge, the choice will be determined partly by the cost for one and the other kind of material and partly by the facilities of manufacture and erection, saving of time in construction, and the cost and facility of maintenance thereafter.

The greater mass of the eye-bar cable over the wire cable is an advantage in respect of rigidity and durability not to be underrated even in a heavy structure like the Manhattan Bridge, in which the dead load is twice the extreme live load.

Nickel steel may be obtained of much greater strength than above specified. So may steel wire be obtained of greater strength than assumed. It will, however, not affect the comparison materially, as the cost of both materials would be correspondingly higher.

	For eye-bar chain.	For steel wire cable.
1. Length of spans	725-1,470-725	725-1,470-725
2. Capacity	Four elevated railroad tracks.	
For electric cars	Four trolley tracks; One roadway, 35 ft. 6 ins.; Two promenades, each 11½ ft.	
3. Width of superstructure	124 ft.	124 ft.
4. Suspension system, four planes of stiffening system, middle span, ¼ deflection	Same.	Same.
5. Weight of floor complete per lin. ft., including buckle plates, flooring, ties, rails, &c.	16,100 lbs.	16,100 lbs.
6. Weight of suspenders and overhead bracing (ordinary steel)	1,400 "	1,400 "
7. Weight of steel required for stiffening, comprising bottom chords, diagonals and extra weight of verticals (ordinary steel) average per lin. ft.	5,250 "	8,135 "*
8. Weight of 4 eye-bar chains, including heads and pins (nickel-steel), average, lin. ft	9,500 "	.....
9. Weight of 4 steel wire cables, including wrapping, covers, and steel bands	.....	4,120 "
10. Total dead load, average per lin. ft., in middle	32,250 lbs.	29,750 lbs.
11. Unit stress in chain or cable from dead load alone, lbs. per sq. in.	23,000 "	46,000 "
12. " " from dead load + 8,000 live load, lbs. per sq. in.	30,000 "	65,000 "
13. " " from dead load + 16,000 live load (which is the extreme), lbs. pr sq. in.	39,000 "	84,000 "
14. Horizontal component from dead load and extreme live load on 4 chains or cables	66,212,000 lbs.	57,176,000 lbs.
15. Deflection under extreme live load in middle span (End span not loaded)	1.93 ft.	2.95 ft.
16. Cross-section of four chains { Maximum	2,440 sq. ins.	.....
{ Minimum	1,872 sq. ins.	.....
17. Cross-section of four cables, maximum†	.....	1,070 sq. ins.
18. Total weight of chains or cables	39,040,000 lbs.	12,034,000 lbs.
19. Cost of cable at 15 cts. per lb.	.....	$1,805,100
20. Cost of eye-bar chain at 6½ cts. per lb.	$1,887,600	.....
21. Cost of additional ordinary steel in the stiffening for wire cable at 5 cts. per lb. (6,370,000 lbs.)	.....	$313,500
22. Cost of additional ordinary steel (166 sq. ins. additional section in each tower) in both towers for eye-bar chains at 5 cts. a lb. (372,000 lbs.)	$18,600	.....
23. Cost of additional masonry (5,000 yds. in each anchor ge) in both anchorages, for eye-bar chain, 10,000 cu. yds., at $7.00	$70,000	.....
24. Totals	$1,976,200	$2,118,600
25. Difference	− $142,400	.....

*The greater weight of steel for stiffening required for cable is by reason of the greater deflections of the wire cable under loads, causing larger bending moments (see item 15).
†Occurs in end spans in the fourth panel from tower.
Note.—For both chains and cables, the maxima include temperature and bending from partial loads.

As the masonry and foundation for the towers are already contracted for and partly built, they do not enter here into the comparison of cost, being the same for chain and cable.

The price of 15 cts. per lb. of cable is based on the cost of that work in the Williamsburg suspension bridge. (Only one bid was received for these cables.) It is believed that the price of 6¼ cts. for the chains of nickel-steel eye-bars is higher than will be obtained in the bids for this work.

The difference in cost between the two designs, one with the nickel-steel eye-bars, and the other with steel wire cables, is therefore $142,400 in favor of the eye-bar chains; but rapid manufacture and erection, and thereafter greater facility of maintenance, are further advantages not to be underrated. For the cable it is assumed that adequate sleeve connections can be made for the web members depending upon friction. But it is doubtful whether that could be done for the large shearing stresses to be transmitted to the cable from the stiffening system. It is a detail not approved by good practice.

As regards time of erection, it may be observed that the eye-bars can be manufactured in advance, and can be ready for erection when the towers are completed by the same contractor. When the chains are completed, no further work is required on them.

Wire cables must be spun in place, a process which requires longer time than the erection of the eye-bar chains. After spinning, the cables must be compacted, wrapped, covered and have the steel bands put on; all of which causes more delay in the erection of the suspended structure.

At the suggestion of the Board, Mr. Lindenthal inquired of all the prominent steel works in the country whether they could furnish the desired quality of nickel-steel. The larger number replied, in effect, that they saw no difficulty in making the desired quality of nickel-steel and the eye-bars.